

Treatment of ectopic eruption of the maxillary first permanent molar in children and adolescents: A scoping review



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Abstract

Aim Ectopic eruption of the first permanent molar (EFUPM) is defined as its local disturbed eruptive behaviour, positioning too mesially against the distal aspect of the second upper primary molar during the developing mixed dentition. The EFUPM prevalence is up to 6% and affects both genders equally. The present study aimed to perform a scoping review to collect the most relevant studies published in the last 30 years and focused on the different strategies, traditional and novel, for treating irreversible uni- or bilateral EFUPM in children. This review also aimed to make recommendations and map the gaps in this clinical topic.

Methods An electronic and manual search was conducted in five databases according to previously established eligibility criteria, using different combinations of keywords, MeSH terms, and Boolean operators. Titles, abstracts, and full-text articles were screened and selected by pre-calibrated reviewers. A data charting was also accomplished for summarising the overview of the evidence.

Results A total of 54 references were identified and 40 titles remained after removing duplicates; then, 31 potential full-text articles were carefully reviewed. Finally, 27 relevant and most informative studies were included. Most studies were case reports and/or clinical treatment descriptions. We also found some descriptive or comparative cross-sectional or cohorts designs. No randomised clinical trials were found.

Conclusions Paediatric dentists must learn to diagnose and treat this condition early in order to allow the prevention of future malocclusions and other clinical sequelae. Practitioners have at their disposal a variety of corrective options available for the successful resolution of EFUPM.

KEYWORDS Ectopic eruption; Maxillary first permanent molar; Clinical management; Scoping review.

Introduction

Several aetiological factors can modify the dental arches' developing process and occlusion during childhood. These alterations may result in dentofacial abnormalities in the future if they are not opportunely treated. The management sequence includes early recognition, clinical and radiographic diagnosis, and appropriate treatment. Eruption guidance during the primary and mixed dentitions is an integral part of comprehensive oral health care provided by the paediatric dentistry practitioner to achieve a normal subsequent occlusal harmony, function, and aesthetics [American Association of Pediatric Dentistry, 2020]. Tooth eruption is a complex process consisting of the migration of the forming tooth from its intraosseous position of development until reaching its functional site within the dental arches [Bruna

del Cojo et al., 2013; Hafiz, 2018]. In this physiological course, multiple factors simultaneously contribute to a successful normal dental eruption [Bruna del Cojo et al., 2013]. The mechanism can be disturbed by different genetic, cellular, molecular, or tissue causes [Hennessy et al., 2012]. If not synchronised, the forces acting on the developing dentition can be unfavourable for reaching a proper occlusion, and a variety of problems can arise during the tooth transitional period; one such problem is ectopic eruption (EE) [Duncan and Ashrafi 1981; Barberia-Leache et al., 2005; Yaseen et al., 2011; Ambriss et al., 2019]. The failure of permanent teeth to properly erupt is due to a range of aetiological causes, such as ectopic positioning or abnormal orientation [Mubeen and Seehra 2018]. Ectopic first upper permanent molar (EFUPM) is a relatively common local condition in which the eruption of the molar occurs under the distal undercut of the adjacent second upper primary molar and its impossibility to erupt to the normal occlusal plane. It was first described by Chapman in 1923 [Chapman, 1923]. Then, in the 50s of the last century, Young established that EFUPM was more frequent in boys than in girls in a significant sample [Young, 1957]. This oral disturbance is usually diagnosed first by the paediatric dentist [Kupietzky, 2000]. Consequently, the EFUPM may become intraosseously impacted and stop emerging, and causing premature resorption, and sometimes the exfoliation, of the second primary molar [Yaseen et al., 2011].

The prevalence of the abnormality has been reported between 1.8% and 6%, affecting both genders equally [Kimmel et al., 1982; Harrison and Michal 1984; Mooney et al., 2007; Salbach et al., 2012; Jariyapongpaiboon and Nuruzzaman 2021; Mitsuhata et al., 2014], with a familial tendency (higher occurrence in siblings) [Bjerklin, 1994; Helm et al., 2021] and present in numerous syndromes [Romano et al., 2016]; also, in children exhibiting concurrent orofacial and dental anomalies, such as cleft palate (with a prevalence four times higher), congenitally missing teeth, supernumerary teeth, and tooth size abnormalities [Da Silva Filho et al., 1996; Mooney et al., 2007; Helm et al., 2021]. Ectopic first permanent molars occur 25 times more often in the maxilla than mandible, and most of these anomalies are of bilateral presentation [Hafiz et al., 2018; Mitsuhata et al., 2014]. The aetiology for EFUPM is still unclear and considered idiopathic. However, it is supposed to be determined by the involvement of both genetic predisposition and environmental aspects, as well as molecular, cellular, or tissue reactions [Salbach et al., 2012; Jariyapongpaiboon and Nuruzzaman, 2021]. It is considered as a multifactorial aetiology condition and includes different local anomalies such as the second primary molar increased size or

atypical crown shape, delayed calcification of the permanent molar, smaller or a more posterior position of the maxilla with respect to the cranial base, insufficient tuberosity growth, and abnormal eruptive angulation of EFUPM with the inadequate anterior movement of primary dentition [Kupietzky, 2000; Mooney et al., 2007; Gonçalves et al., 2012; Hafiz, 2018; Helm et al., 2021]. A diagnosis of this local condition is made based on combined clinical and radiographic findings. There are two types of EFUMP: reversible or self-correcting when the ectopic molar unlocks and eventually comes into occlusion; and irreversible when the ectopic molar remains locked until either the premature exfoliation or extraction of the second primary molar occurs. One-third of EFUMP is irreversible, so interceptive orthodontic treatment must be implemented in order to redirect the eruption path while maintaining the resorbed primary molar [Dabbagh et al., 2017; Kim et al., 2020]. Thus, space loss, posterior crowding, and impaction of the upper second premolar might be prevented in the future.

To our knowledge, no detailed up-to-date summary of the evidence regarding the treatment of EFUPM in children is available. In this context, and considering that EFUPM is a very important cause for malocclusions, the present scoping review intends to collect those most relevant studies from the dental literature, published in the last 30 years, focused on the prevalence and other features, and on appraising the different strategies, both traditional and novel, implemented for the resolution of irreversible EFUPM. Also, this review aims to make recommendations and to map the gaps in this clinical topic.

Methods

The present scoping review was carried out according to the methodology stated by Arksey and O'Malley [2005], Levac and co-workers [2010], and the Preferred Reporting Item for Systematic Reviews and Meta-analysis extension for scoping reviews guidelines (PRISMA-ScR) [Tricco et al., 2018] for transparent reporting. A scoping study comprises a further type of literature review, whose main purpose is to map relevant literature and the key concepts underpinning a clinical topic of interest. Also, the main sources and types of evidence available, especially when this topic has not been reviewed comprehensively before. In general, a scoping review consists of five steps as follows.

1. Constructing the research question.
2. Identifying relevant studies.
3. Study selection.
4. Charting the data.
5. Collating, summarising, and reporting the results.

Nowadays, scoping reviews represent an increasingly popular approach to reviewing dental research evidence. Scoping studies differ from systematic reviews because authors do not assess the quality of included studies; scoping studies also differ from narrative literature reviews in that the scoping process requires analytical reinterpretation of the literature [Levac et al., 2010].

Eligibility criteria

The study followed a PCC format scoping review question, where the population (P) was "children"; concept (C) was "in mixed dentition stage with one or two EFUPM"; and context (C) was "clinical trials/ observational studies/ narrative review articles/ on orthodontic treatment". Only electronic available randomised controlled clinical trials, observational studies (cohort, case-control, cross-sectional designs), and narrative reviews and/or clinical case reports, written in the English language, and published

between 1990 and 2021 were eligible. Publications focused on the treatment of EFUMP in which the authors explored and described the different clinical strategies for the resolution of the condition in the mixed dentition stage were chosen. Studies performed in permanent dentition or adults, letters to the editor, and gray literature were excluded. Reasons for exclusion after full-text reading were recorded.

Search strategy and screening process

An electronic search from the period from April to July 2021 was performed in the following four databases: PubMed, Cochrane Library, Google Scholar, and Dentistry & Oral Sciences Source (EBSCO) for reviews, clinical trials, and observational studies. A search strategy was conducted, employing different combinations of keywords (and synonyms), MeSH terms, and Boolean operators. The main four key search terms were "children", "ectopic eruption", "first maxillary permanent molar", and "treatment". We adapted this strategy for use in all electronic databases. For instance, in PubMed, the following search algorithm was employed: "ectopics"[All Fields] OR "ectopic"[All Fields] OR "ectopical"[All Fields] OR "ectopically"[All Fields] AND ("erupt"[All Fields] OR "erupted"[All Fields] OR "erupting"[All Fields] OR "eruptions"[All Fields] OR "eruptive"[All Fields] OR "erupts"[All Fields] OR "tooth eruption"[MeSH Terms] OR ("tooth"[All Fields] AND "eruption"[All Fields]) OR "tooth eruption"[All Fields] OR "eruption"[All Fields] AND (("first"[All Fields] OR "firsts"[All Fields]) AND ("maxilla"[MeSH Terms] OR "maxilla"[All Fields] OR "maxillary"[All Fields] OR "maxillaries"[All Fields] OR "maxillaris"[All Fields]) AND ("permanent"[All Fields] OR "permanently"[All Fields] OR "permanents"[All Fields]) AND ("molar"[MeSH Terms] OR "molar"[All Fields] OR "molars"[All Fields] OR "molar s"[All Fields])) AND ("child"[MeSH Terms] OR "child"[All Fields] OR "children"[All Fields] OR "child s"[All Fields] OR "children s"[All Fields] OR "childrens"[All Fields] OR "child"[All Fields]) AND (("orthodontal"[All Fields] OR "orthodontic"[All Fields] OR "orthodontical"[All Fields] OR "orthodontically"[All Fields] OR "orthodontics"[MeSH Terms] OR "orthodontics"[All Fields]) AND ("treatment"[All Fields] OR "treated"[All Fields] OR "treatments"[All Fields] OR "managing"[All Fields] OR "management"[All Fields])

The complete searching process was carefully carried out by two independent and pre-calibrated authors (PBV and MARB), according to the inclusion and exclusion criteria. The levels of inter- and intra-observer agreement of these authors were determined using Cohen's kappa coefficient [Cerdá et al., 2010]. Any discrepancy or conflict of opinion was resolved through discussion and consensus by consulting with the other two authors (AJPG and JAGR).

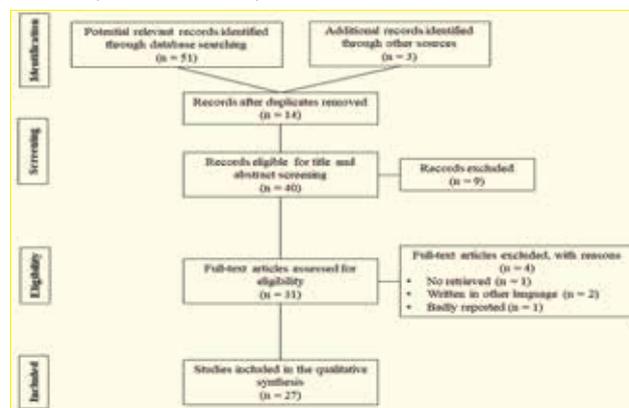


FIG. 1 PRISMA flow chart for literature search.

Data charting and result synthesis

A special tabular form for data charting was constructed and piloted with relevant information entries, and approved by authors' consensus. From each selected article, the following items were summarized and recorded: publication first author and year, country, study methodological design, intervention(s), outcomes, and main findings/conclusions; in cases of observational (cross-sectional or longitudinal) studies, target population, sample size and follow-up period (e.g. cohort designs) were also taken. All items were collected independently by two authors (AJPG and JAGR).

Results

A total of 54 references were identified in the different electronic databases, after which 40 titles remained after removing duplicates. After the article title and abstract screening, 31 potential full-text articles were carefully reviewed. Finally, 27 relevant and most informative studies—according to the authors' experience (no critical appraisal was carried out)—were included in the present scoping review. The selection process was according to the PRISMA-ScR statement flowchart, as can be seen in figure 1. On the other hand, good to very good intra- and inter-reviewer agreement levels were found for the search strategy and screening processes, according to the kappa coefficients (0.86 and 0.92, respectively). Sixteen studies were case reports and/or clinical treatment descriptions, six descriptive or comparative cross-sectional designs, four cohorts, and one narrative review; no randomised clinical controlled trials were detected. Regarding the country, most articles were conducted in Brazil, Central Asia (mainly in India, Turkey, and South Korea) and Europe. Eight studies presented any type of descriptive or inferential statistical analysis (with p values). The publication dates ranged from 1992 to 2021. Principal characteristics, numerical data, and findings, and conclusions from these articles are summarised in Tables 1 (1991–2000), 2 (2001–2010), and 3 (2011–2021).

Discussion

A variety of eruption disorders can occur during the transitional period in which the primary dentition is replaced by the permanent one, such as the abnormal eruption of permanent teeth, mainly upper first molars, canines, and incisors; these phenomena should be stressed in contemporary paediatric dentistry [Kupietzky, 2000; Nagaveni et al., 2010; Mitsuhashi et al., 2014; Kim et al., 2020]. Therefore, paediatric dentists must recognise uni- or bilateral EFUPM in the early stages, so that they may initiate the indicated corrective treatment at the proper time [Harrison and Michal 1984].

By conducting the present scoping review, the authors pretended to identify and summarize the existing literature evidence published in the last 30 years and to provide an updated descriptive analysis or synthesis of those studies related to the clinical management of EFUPM in children.

EFUPM is a painless and commonly unrecognised anomaly, usually or incidentally diagnosed on the routine radiographic examination in the early mixed dentition, from 6 to 7 years of age [Nagaveni et al., 2010; Nam et al., 2015; Jariyapongpaiboon and Nuruzzaman 2021]. As mentioned above, this local condition is grouped as self-correcting (or "jump type") or irreversible impacted (or "hold type"), according to different clinical and radiographic features [Young, 1957; Kupietzky, 2000; Salbach et

al., 2012; Romano et al., 2016]. In this regard, Barberia-Leache et al. [2005] proposed an EFUPM classification, according to the magnitude of the adjacent primary second molar, into four grades as follows.

1. Mild: limited resorption to cementum with minimal dentin penetration.
2. Moderate: resorption of dentin without pulp exposition.
3. Severe: pulp exposure in the distal root;
4. Very severe: resorption of the mesial root.

The first two grades tend to be resolved spontaneously, but the severe and very severe types do not, and present the worst prognosis ("the more mesial the position, the greater the time need to correct it") [Romano et al., 2016]; however, this is not a strict rule. These and other authors also mention that when a middle or less of the marginal border of the permanent molar is locked, it usually self-corrects by age 7 or 8 (even up to 9) [Mooney et al., 2007; Haznedaroğlu and Mentez 2016; Dabbaugh et al., 2017]; and that, in about 80% of cases of EFUPM, the damage to the primary molar is severe or very severe [Barberia-Leache et al., 2005]. Besides, it has been mentioned that the chance of root resorption is higher if the molar impaction occurs below the second primary molar's cement-enamel junction [Gonçalves et al., 2012]. Although treatment timing is critical and should coincide with the active phase of the first permanent molar eruption, it is always advisable to closely monitor each case individually for three to six months, mainly at ages between 7 and 8 years, looking for delayed eruptions or asymmetry in the eruption process of one or more first permanent molars [Mucedero et al., 2015; Mooney et al., 2007; Nagaveni et al., 2010; Hennessy et al., 2012].

In addition to causing premature exfoliation of the second primary molar, delayed eruption or impaction of the second premolar, and space loss [Hennessy et al., 2012], EFUPM is considered as a risk factor for maxillary arch constriction and severe transverse (e.g. lateral crossbite) and sagittal crowding [Salbach et al., 2012]. Furthermore, it has been suggested that irreversible EFUPM accompanied by severe primary molar resorption is a potential early indicator of abnormal canine eruption and the subsequent lateral or central incisor root resorption. This association was found in 23.3% of the children in the study conducted by Becktor and co-workers; the authors concluded that these patients exhibited a biological and/or genetic dysfunction of the ectoderm which troubled the development of both permanent upper first molars and canines [Becktor et al., 2005; Salbach et al., 2012]. In this same regard, Salbach and co-workers found a significant correlation (more than 70%) between the disturbed eruption of the upper first permanent molar and Class III malocclusions; again, irreversible EFUPM can be considered as an early indicator of this type of malocclusion [Salbach et al., 2012]. On the other hand, retention, transmigration, and ectopic eruption of permanent teeth in children have been associated with odontogenic tumors (e.g. odontomas) [Marra et al., 2021].

A myriad of corrective techniques for treating irreversible EFUPM have been proposed. The paediatric dentist should consider four main factors before choosing an orthodontic strategy [Hennessy et al., 2012]. First, the age of the patient; if a spontaneous correction does not occur within six months, it may be assumed an irreversible condition. Second, the status of the second primary molar (irreversible pulpitis or increased abnormal mobility). Third, the presence of the second premolar; if this tooth is missing, it may be recommended to extract the second primary molar and allow the first permanent molar to erupt mesially close the resultant space. And fourth, the severity of impaction; as mentioned before, grades II and IV require active treatment, and sometimes the extraction of the adjacent primary molar. Thus and

Article Country	Design	Aim (s) and Intervention (s)	Sample size Population	Follow-up	Outcomes
Wein-berger, 1992, Canada	Descriptive (description of an orthodontic technique)	To describe the use of a fixed appliance to correct a bilateral EFUPM: - A transpalatal bar with an acrylic button; distal extensions (0.036inch-wire) with soldered hooks at their ends; bonded buttons and chain elastics. - Elastic chains are changed every three weeks. - The treatment active phase to achieve full correction is less than two months. One additional month is necessary for retention.	NA Children in mixed dentition stage.	NA	- Advantages of this appliance: (1) No force is applied in the second molar. (2) Treatment can be started unilaterally when only one molar is sufficiently erupted. (3) Only the occlusal surface of the first permanent molar needs to be bonded.
Hirayama, 1992, USA	Descriptive (description of an orthodontic technique)	- To describe the use of a fixed appliance to correct a bilateral EFUPM:	NA 71/62.3	About 6 months	1- If the ectopic molar is not too subgingival, the elastic separator is preferred. If it is too subgingival, the metal one is the first choice. - There are three sizes of metal separators: 0.018, 0.020, and 0.022 round stainless steel wire. - Separators should be replaced sequentially by smaller ones.
Bjerklin, 1994, Sweden	Prospective cohort	- To investigate the prevalence, familial tendency, and etiological or associated factors of EFUPM (such as cleft lip/palate), and - To determine orthodontic treatment effects, through: - Radiographic and clinical assessments. - Biometrics. - Histological evaluation. - Statistical analysis.	2,903 Children (mean age 8.3 years) with and without cleft lip and/or palate. - 45 children received orthodontic treatment with cervical headgear	10 years	Prevalence of EFUPM: 4.3 % and 21.8 (for cleft children); 19.8% in siblings. - Main etiological factors were (1) greater mesial angulation, and (2) larger width of the ectopic molar. - Almost all the atypically resorbed second upper primary molars remained in the dental arch until normal exfoliation. - Orthodontic treatment (average time of 9 months) was effective for up-righting the EFUPM to good occlusion; 70% gained sufficient space for the second premolar
Bjerklin, 1995, Sweden	Prospective cohort Non-randomized clinical trial	To evaluate the long-term effects of early orthodontic treatment	91 Children (6.5 to 9.9 years old) with irreversible EFUPM - 45 treated with cervical traction headgear for 8 to 12 months, - 46 untreated controls	10.9 to 12.0 months	- Up-righting of mesially tipped EFUPM was achieved, until reaching normal molar occlusion, during treatment - The mesial angulation decreased 8-14 degrees during the follow-up period - All treatment side-effects were eliminated
Huang, 1995, USA	Descriptive (description of an orthodontic technique)	- To introduce a clinical aid in placing a brass wire to pass apically to the contact between the primary and permanent molars, through a pre-curved angiocatheter (0.020 to 0.022 gauge).	NA Children in mixed dentition stage.	NA	Advantages of this technique: (1) It eliminates the need for impression and laboratory procedures. (2) It reduces the difficulty in inserting the brass wire, preventing distortions. (3) Both components can be prepared easily and quickly
Gungor, 1998, Turkey	Brief literature review. - Report of two clinical cases of EFUPM	To present one case of bilateral EFUPM in which a removable appliance was used for distalization and up-righting. The appliance consisted of Adam's with a soldered vestibular arch; and two cantilever springs (0.7 mm wire), which ends were mesiodistally flattened, for distal movement. The ends were arched over the gum to achieve maximum surface contact with the EFUPM mesial surface; two 0.6 mm wires were placed to guide and control the movement. The springs were activated 0.5-1 mm every 10 days.	NA An 8.3-year-old boy	Not specified	Both primary second molars were extracted before orthodontic treatment. - The appliance was used 24 hours a day. - Active treatment: 4 months. - A Nance arch was then placed for retention
Kupietzky, 2000, Israel	Brief literature review - Clinical orthodontic treatment description	To describe in detail, step-by-step, the brass wire technique	NA	Not specified	The orthodontic procedure is explained in 10 single steps. - Brass wire (0.020 or 0.025 (it can also be prepared from a 0.028 coil of wire, by flattening out one end with a How plier). - The wire is placed between the impacted molar and the adjacent second primary molar. Sometimes, local anesthesia is required. - Wire tightening every 3-4 weeks

TABLE 1 Characteristics of the included studies (1990-2000).

according to the collected findings, some orthodontic corrective procedures are economic, fast, and simple, but others are too complicated, costly, and need substantial time on the dental chair or require a lot of compliance from the patients. In general, treatment modalities are classified into two types [Weinberger, 1992; Hennessy et al., 2012]: interproximal wedging (indicated for minimal impactions) and distal tipping (re-establishment of the correct erupting axis) for severe impactions. Interproximal wedging includes brass wires, spring-type deimpactors, helical springs, bonded light wires, and Kesling or elastic separators. Also, the placement of preformed crowns or bands on the adjacent primary molar, acting as an inclined plane against the erupting EFUPM; even the distal reduction/grinding of the second primary molar has been recommended [Kuroi, 2002; Mooney et al., 2007; Kim et al., 2020]. Whereas distal tipping mainly comprises space maintainers, regainers, or uprighting techniques. For instance, removable Hawley-type appliances, well-anchored fixed devices with accessories (transpalatal arches, distal arms/hooks, or finger springs; together with bonded lingual buttons for elastomeric chains), original and modified Humphrey's appliance, Halterman's appliance, Croll's appliance, uni or bilateral reversed band and loop with a distal spur, K-loops, flexible sectional nickel-titanium wires with open coil spring, cervical headgear traction [Huang et al., 1995; Bjerklin, 1994; Nam et al., 2015], and other innovative

designs mentioned here. However, few systematic or clinical comparative studies of treatment modalities for EFUPM and their effects on children have been published. According to the findings and opinions of the reviewed studies, the "ideal" orthodontic technique for EFUPM in children would have the following desirable requirements.

- Be performed in only one visit.
- Conservative, simple, quick, and cheap fabrication.
- No impressions or minimal laboratory work.
- Adequate anchorage; the distal and extrusive movements of an EFUPM cause equal and opposite forces, resulting in likely unwanted displacements of the supporting primary molars.
- Preferably without band placement.
- Minimal adjustment or activation sessions.
- Self-cleansing.
- Minimal patient cooperation; for example, in cases of using extraoral appliances (e.g. cervical headgear).
- No damage to surrounding soft tissues; for example, the Nance appliance can produce mucosal inflammation or hyperplasia, and sometimes pain, beneath the acrylic button.
- In cases of unilateral appliances, it also should be safe, preventing possible detaching and ingesting/aspirating.

Although none of the reported treatment modalities in the present scoping review meet all of these requirements, they

Article Country	Design	Aim (s) and Intervention (s)	Sample size Population	Follow-up	Outcomes
Barberia-Leache, 2005, Spain	Descriptive cross-sectional	- To describe the characteristics and occurrence of EFUPM and the association with the abnormal resorption degree of the second primary molar. Clinical oral examination.- Crown measurements in bitewing radiographs and dental casts	509 Spanish children (6-9 years old)	NA	EFUPM prevalence: 4.3%; it was bilaterally in 63.6 % of cases. - 69.4% of cases self-corrected. - Mean impaction on the right side: 2.91 mm; on the left side: 1.6 mm. - Spontaneous self-correction occurred without arch length loss
Mooney, 2007, UK	Descriptive cross-sectional	- To investigate the features of EFUPM and its associations with other dental abnormalities (primary molar infraocclusion, hypodontia, cleft lip/palate, and supernumerary teeth.	48 British children (7-11 years old): - 28 with EFUPM - 20 controls	NA	50% of EFUPM children exhibited two ectopic molars. - 60.7% were found to have one or more dental anomalies. - Infraocclusion and cleft lip/palate were significantly more frequent in the ectopic group than in controls
Nagaveni, 2010, India	Clinical case report and description of an orthodontic technique	clinical case with a left EFUPM with severe resorption of the second molar. - A Humphrey's appliance (S-shaped loop 0.006-inch wire) is incorporated into a fixed Nance's button arch. - The loop wire is placed and bonded in a small occlusal preparation on the permanent molar for its distalization.	NA An 8.5-year-old girl	3 months of active treatment	Humphrey's appliance usually takes 3-4 months to complete the distalization process; it should be activated every 2-3 weeks. The end of the S wire must properly engage the pit of the EFUPM; otherwise, a small shallow cavity is prepared. Before its bonding, the clinician must evaluate for proper fit, without occlusal interferences. After bonding, the excess cement should be removed to prevent gingival inflammation

TABLE 2 Characteristics of the included studies (2001-2010).

have been demonstrated to be clinically effective and safe. Thus, the practitioner can perform a careful selection process of the best orthodontic approach, after considering the clinical/radiographic oral features of the case, the level of cooperation, and the advantages and disadvantages of each strategy. Their decision should satisfy not only the individual clinical circumstances or potential sequelae but also the patient's well-being [Ambriss et al., 2019].

A representative example of EFUPM treatment is illustrated in Figure 2. When a permanent tooth is impacted, a multidisciplinary approach of surgery and orthodontic management is the best mode to obtain a suitable outcome, in terms of gingival contour, occlusal plane, and esthetics [Attardo-Parrinello et al., 2020]. So, clinicians need to possess detailed knowledge and information of the several issues related to EFUPM, which can help to obtain an accurate diagnosis and to plan an effective treatment [De Mendonça et al., 2021]. Furtherly, they need to be aware of the disorder through routine and periodic examinations from 5.5 years old. Once the proper diagnosis is early established, the treatment must be immediately initiated, when the first permanent molar has its roots incompletely formed and the second permanent molar is not still ready to erupt [Gutiérrez-Marín, 2021].

Limitations

The present scoping review carefully followed the recommendations stated by Arksey and O'Malley [2005] for screening specific papers and extracting relevant data from them. However, and as in any scoping review, a significant weakness is that a critical methodological quality and the risk of bias of each selected article cannot be assessed. Additionally, only clinical case reports, narrative reviews, and observational studies were included; these methodological designs are prone to diverse bias and confounding. We also limited published articles to the English language articles; so, other language relevant studies could be missed. Despite these limitations and the fact that no randomised clinical trials were found, we are confident that sufficient reliable and useful information could be collected and synthesized, to aid clinicians in better understanding the clinical management of EFUPM in children.

Conclusions

Paediatric dentists have at their disposal a variety of corrective alternatives available for the successful resolution of EFUPM. If EFUPM is opportunely detected and treated, there will be



FIG. 2 Seven-year- 8-month old boy with the first right upper permanent molar with severe ectopic eruption, below the distal contour of the second primary molar. There was significant reabsorption of the distal root of the primary molar with no mobility. A 4-mm elastic separator (Ormco™) was placed between the molars for 5 months, with monthly replacement. After 6 months, it was possible to correct the ectopic position of the permanent molar, while the primary second molar was kept in the mouth, without mobility, sensitivity, or pain. After a year, the permanent first molar remains in a good position and the primary second molar is asymptomatic (reproduced with permission from Gutiérrez-Marín N. Corrective treatment of ectopic eruption of permanent first molars: Case report. Int J Dent Sci (ODOVTOS) 2021;23:19-26).

more chances to limit the extent of malocclusions and to reduce the possibility of further lengthy, aggressive, and complicated orthodontic/orthopaedic treatment.

Conflict of interest

The authors declare that they have no conflicts of interest.

References

- Ambriss B, Moukarzel C, Noueiri B. Management of bilateral ectopically erupting maxillary molars: A case report. Int J Clin Pediatr Dent 2019;12:153-6.
- American Academy of Pediatric Dentistry. Management of the developing dentition and occlusion in pediatric dentistry. Reference Manual. Pediatr Dent 2020;44:393-409.
- Arksey H, O'Malley L. Scoping studies: Towards a methodological framework. Int J Soc Res Methodol 2005;8:19-32.
- Attardo-Parrinello MM, Lucarelli D, Colombo S, Mancini GE, Gianni AB. Impacted post-traumatic maxillary central incisor: A multidisciplinary approach. Eur J Paediatr Dent 2020;21:209-12.
- Barberia-Leache E, Suárez-Clúa MC, Saavedra-Ontiveros D. Ectopic eruption of the maxillary first permanent molar: Characteristics and occurrence in growing children. Angle Orthod 2005;75:610-5.
- Becktor KB, Steiniche K, Kjaer I. Association between ectopic eruption of maxillary canines and first molars. Eur J Orthod 2005;27:186-9.

Article Country	Design	Aim (s) and Intervention (s)	Sample size Population	Follow-up	Outcomes
Hennessy, 2012, Ireland	Literature narrative review	To describe the different management alternatives for EFUPM using clinical examples	NA	NA	Different treatment options for EFUPM: (1) Interproximal wedging (brass wires). (2) Elastomeric separators. (3) Kesling separator.* (4) Transpalatal arch with a distal hook. (5) Variations and modifications of fixed appliances
Salbach, 2012, Germany	Prevalence / Correlation cross sectional	To determine the frequency of eruption disorders in the first permanent molar region- To establish the risk factors for compromised dental development from frequency and age correlates	8,041 Kindergarten and school children aged 5-9 years	NAs	102 children exhibited any eruption disturbance of the first permanent molar; 88.5% of the maxillary molar was involved, particularly in the bilateral form.- 72.6% presented at least one additional malocclusion (e.g. crowding and lateral malocclusion)
Thakur, 2012, India	Clinical case report and description of an orthodontic technique	To illustrate a new simple distal tipping technique for the correction of an EFUPM - A light cure composite dimple with a tunnel-like opening on the mesial side is bonded to the buccal surface of the impacted molar - A nickel-titanium archwire (0.016) segment is bonded to the buccal of the first primary molar. - The distal end of the wire is forced into the tunnel, creating thus a "loop" that activates the wire	NA An 8-year-old girl	1 year (6 weeks of active treatment)	Advantages of the technique: (1) It does not require bands or any laboratory work. (2) It does not need any type of activation or adjustment. (3) It is a simple, quick, no injurious, and self-cleaning appliance.
Goncalvez, 2012, Brazil	Clinical case report and description of an orthodontic technique.	- To report the ectopic eruption of an EFUPM with severe root resorption of the adjacent primary molar. A twist brass wire between both molars, activated at days 0, 15, and 30	NA A 9-year-old girl	2 years	The second primary molar did not exhibit any signs or symptoms of pulp damage; so, it was decided to retain it until normal exfoliation - The orthodontic technique is a low-cost approach and the active treatment is short (less than a month and a half in this case).
Mucedero, 2015, Italy	Comparative (and randomized) cross-sectional design	- To analyze the prevalence and distribution of EFUPM - To investigate the association of dental characteristics, maxillary skeletal features, and tooth crowding - Five dental or skeletal parameters were measured: (1) Mesio-distal (M-D) crown width of the second upper primary molar. (2) Mesio-distal (M-D) crown width of the first permanent molar. (3) Maxillary and mandibular crowding. (4) Maxillary arch length (A-PML). (5) Anterior and posterior maxillomandibular transverse skeletal relationships (ATID and PTID).	1317 Children aged 7-10 years, scheduled for orthodontic treatment: - 265 as controls. - 1052 in the experimental group. From these, 26 were diagnosed with one or two EFUPM (reversible or irreversible)	NA	Prevalence of EFUPM: 2.5%. - In the experimental group: - M-D crown widths, ATID, PTID, and dental crowding were significantly greater. - A-PML was significantly smaller. - Two subjects exhibited an association with maxillary tooth anomalies (agenesis and microdontia). - EFUPM can be considered as a risk factor for maxillary arch constriction and severe tooth crowding
Nam, 2015, South Korea	Clinical case report and description of an orthodontic technique	To report a correction of an EFUPM using a K-loop, with severe root resorption of the second primary molar. - K-loop is a double-loop rectangular (0.016 x 0.022) TMA segment wire - It is ligated to the banded second primary molar (with a welded single tube) and then bonded to the occlusal surface of the ectopic molar - The wire is mesially prolonged up to the first primary molar and canine and also bonded to their buccal surfaces for increased retention and anchorage	NA A 7-year-old boy	-	This is a simple, comfortable, and easy technique - Through its two loops, the K-loop exerts light and continuous three-dimensional forces - Active treatment: 4 to 8 weeks
Haznedaroğlu, 2016, Turkey	Clinical case report and description of an orthodontic technique	To describe the orthodontic treatment for a child with bilateral EFUPM. - The treatment included two steps: (1) Stripping the distal surfaces (about 2 mm) of both primary second molars with carbide burs, under local anesthesia. (2) Placement of a modified Hawley appliance with C-shaped clasps at the distal ends; these clasps were engaging the mesiobuccal undercuts of both EFUPM and activated for distalization	NA An eight-year-old girl	6 months	The modified Hawley appliance is indicated in cases where: (1) Permanent first molars are locked on the distal end of the adjacent primary molar. (2) When the patient is unwilling to use a more complicated appliance - The appliance is safe and easy to use but child compliance is essential.
Romano, 2016, Brazil	A two clinical cases report and a description of an orthodontic technique	To describe two cases of EFUPM treated with a modified Nance Palatal Arch placed on the primary second molars, for light distal movements and space recovery - The arch possesses a posterior hook (a 0.7 mm wire segment soldered to the band) for elastic chains. This wire is prolonged mesially and bonded to the buccal surfaces of the primary first molar and canine for additional anchorage - An orthodontic button is bonded to the occlusal surface of the impacted molar	NA Two children: 8.2 and 9.0-year-old	About 3 months	In both cases, the primary second molars could be maintained in place after treatment - The elastic chain should be changed every 15 days - Advantages of the appliance: (1) It can control the distal and occlusal movements of the permanent molar. (2) No dependency on the patient's cooperation. (3) It does not affect esthetics - Disadvantages: (1) It may hinder oral hygiene

TABLE 3A Characteristics of the included studies (2011-2021).

- › Bjerklin K. Ectopic eruption of the maxillary first permanent molar. An epidemiological, familial, aetiological and longitudinal clinical study. *Swed Dent J* 1994;100(Suppl):1-16.
- › Bruna del Cojo M, Gallardo-López NE, Mourelle-Martínez MR, De Nova-García MJ. Time and sequence of eruption of permanent teeth in Spanish children. *Eur J Paediatr Dent* 2013;14:101-3.
- › Cerda J, Villarreal L. Evaluation of the interobserver concordance in pediatric research: the Kappa Coefficient. *Rev Chil Pediatr* 2008;79: 54-8.
- › Chapman MH. First upper permanent molars partially impacted against second deciduous molars. *Int J Oral Surg* 1923;9:339-45.
- › Da Silva Filho OG, De Albuquerque MV, Kuroi J. Ectopic eruption of maxillary first permanent molars in children with cleft lip. *Angle Orthod* 1996;66:373-80.
- › Dabbagh B, Sigal MJ, Tompson BD, Titley K, Andrews P. Ectopic eruption of the permanent maxillary first molar: Predictive factors for irreversible outcome. *Pediatr Dent* 2017;39:215-8.
- › De Mendonça MR, Aparecido-Cuoghi O, Veloso de Linhares AP. Evaluation of the mesio-distal positioning of the maxillary first permanent molar in individuals with ectopic eruption. *Res Soc Develop* 2021;10:1-6.
- › Duncan WK, Ashrafi MH. Ectopic eruption of mandibular first permanent molar. *J Am Dent Assoc* 1981;102:651-4.
- › Goncalvez RA, Ardenghi-Vargas IA, Castilhos-Ruschel H. Clinical management of the ectopic eruption of a maxillary first permanent molar – Case report. *Stomatol* 2012;18:16-25.
- › Gungor HC, Altay N. Ectopic eruption of maxillary first permanent molars: Treatment options and report of two cases. *J Clin Pediatr Dent* 1998;22:211-6.
- › Gutiérrez-Marín N. Corrective treatment of ectopic eruption of permanent first molars: Case report. *Int J Dent Sci (ODOVTOS)* 2021;23:19-26. DOI 10.15517/IJDS.2020.40778
- › Güven Y. Prevalence of ectopic eruption of first permanent molars in a Turkish population. *Eur Oral Res* 2018;52:1-5.
- › Hafiz ZZ. Ectopic eruption of the maxillary first permanent molar: A review and case report. *J Dent Health Oral Disord Ther* 2018;9:154-8.
- › Harrison LM Jr, Michal BC. Treatment of ectopically erupting permanent molars. *Dent Clin North Am* 1984;28:57-67.
- › Haznedaroğlu E, Mentez A. A simplified method for eruption of the ectopic molars: A case report. *J Dent App* 2016;3:312-4.
- › Helm A, Martín-Vacas A, Molinero-Mourelle P, Caleyá AM, Gallardo NE, Mourelle-Martínez MR. Ectopic eruption of maxillary first permanent molars: Preliminary results of prevalence and dentoskeletal characteristics in Spanish paediatric population. *Children* 2021;8:479-86.
- › Hennessy J, Al-Awdhi EA, Dwyer LO, Leth R. Treatment of ectopic first permanent molar teeth. *Dental Update* 2012;39:656-8.
- › Hirayama K, Chow MH. Correcting ectopic first permanent molars with metal or elastic separators. *Pediatr Dent* 1992;14:342-4.
- › Huang WJ, Childers NK. Clinical aid in placing brass wires to treat ectopically erupting permanent first molars. *Ped Dent* 1995;17:122-3.
- › Jariyapongpaiboon S, Nuruzzaman K. Management of ectopic eruption of maxillary

Article Country	Design	Aim (s) and Intervention (s)	Sample size Population	Follow-up	Outcomes
Dabbagh, 2017, Canada	Retrospective cohort	To determine the rate of self-correction of EFUPM and the possible clinical factors to predict an irreversible molar impaction. - A cohort of patients treated in a private dental office between 2000 and 2012. - The patients had no still received any type of orthodontic treatment - Predictive factors studied: gender, age at diagnosis, age at the outcome of EFUPM, unilateral or bilateral occurrence, primary occlusion characteristics, primary molar occlusion, primary canine occlusion, and Baume arch type.	65 Children with a radiographic diagnosis of EFUPM and followed-up until the outcome of the condition or for a minimum of two years	2 years	- 45 (1%) patients self-corrected; one-third of them occurred at 9 years old - 18 (28%) patients increased molar impaction - Correlated predictive factors of irreversible ectopic eruption: (1) Increased magnitude of impaction. (2) Degree of primary molar resorption. (3) Severe lock. (4) Bilateral occurrence.
Güven, 2018, Turkey	A radiographic cross-sectional study	To investigate the prevalence and features of EFUPM in a Turkish child sample (2010-2013). - Performed on panoramic radiographs - Studied features: age, gender, number of EFUPM, unilateral/bilateral occurrence, resorption degree of the adjacent primary molar, and other dental anomalies	7649 Patients (5-11 years old) with erupted first permanent molars	NA	102 children exhibited any eruption disturbance of the first permanent molar; 88.5% of the maxillary molar was involved, particularly in the bilateral form. - 72.6% presented at least one additional malocclusion (e.g. crowding and lateral malocclusion)
Hafiz, 2018, Saudi Arabia	Brief literature review - Clinical orthodontic treatment description and case report.	To present a case of an irreversible, EFUPM treated with the extraction of the adjacent primary molar due to significant root resorption and subsequent pulp involvement - A reverse band and loop space maintainer between the first primary molar and the mesial aspect of the EFUPM - The distal end of the wire is forced into the tunnel, creating thus a "loop" that activates the wire	NA A 7.5-year-old girl	1.5 years	The treatment preserved the available space for the correct placement of the premolars and guided the eruption path of the ectopic permanent molar.
Ambriss, 2019, Lebanon	Clinical orthodontic treatment description and case report	To describe an irreversible bilateral EFUPM with severe root resorption of the second primary molar - A modified Croll's appliance was employed to perform distal tipping of both locked molars - This is a fixed appliance banded to the first primary molars; with distal extensions and hooks (0.036 wire), placed 2-3 mm behind the permanent molars, for elastic chains - It also comprises a transpalatal with an acrylic button - Two orthodontic buttons are bonded to the mesio-occlusal surface of both permanent molars - The elastic chains are shortened every two weeks.	NA An 8-year-old boy	6 months	Active treatment: 6-8 weeks - The transpalatal arch can preserve the leeway space - Disadvantages of this appliance: (1) It requires an extended chairside and laboratory time. (2) Good isolation for adequate button bonding can be difficult. (3) Frequent changes of elastics are needed
Kim, 2020, South Korea/USA	Clinical orthodontic treatment description and case report	- To present a novel orthodontic approach for unlocking EFUPM. - A 0.012-inch nickel-titanium wire is compressed and bent gingivally before its bonding to the permanent and second primary molars. Also, the second primary molar is splinted to the primary first molar and canine with a bonded passive 0.0195-inch multi-stranded wire, to reinforce the anchorage	NA An 8-year-old boy	4 months	Active treatment: 2 months - The appliance worked, although the distal of the primary molar was considerably resorbed - This technique is simple and inexpensive, exerts light continuous forces, and does not require laboratory procedures - It is indicated for mild-to-moderate impactions
Jariya-pongpaiboon, 2021, Thailand	Clinical orthodontic treatment description and case report.	To present a case with unilateral EFUPM and severe root resorption of the adjacent molar, treated with the Halterman appliance with a transpalatal arch - The transpalatal arch was cemented in the second primary molars; a distally extended wire arm with a hook at the end is soldered to the buccal aspect of the band - The hook holds an elastomeric C-chain for distal traction and tipping of the impacted molar - A metal lingual button is bonded on the occlusal surface of the EFUPM	NA A 7.8-year-old boy	1 year	- The elastomeric chain exerted a force of 50 g; it was changed every week - Active treatment: 2 weeks - A possible disadvantage of the original unilateral Halterman appliance is the loss of anchorage that causes mobility of the second primary molar; the addition of the transpalatal arch avoids this
Gutiérrez-Marín, 2021, Costa Rica	Clinical orthodontic treatment description and case report.	- To determine the prevalence of EFUPM in children. - To evaluate the possible association with diverse dentoskeletal characteristics. - The used digital panoramic radiographs and lateral skull teleradiograph for Rickett's cephalometric analysis.	322 Children aged 6-9 years	NA	Prevalence of EFUPM: 8.7%; bilateral presentation was significantly more prevalent than unilateral - The highest prevalence was in the 7-year-old group - Main radiographic/cephalometric features in the ectopic group: (1) Shortened anterior cranial base. (2) Maxillary retroposition. (3) Distal position of the first permanent molar regarding the pterygoid vertical plane. (4) Decreased palatal plane. (5) Distal position of the upper incisors
De Mendonça, 2021, Brazil	Comparative cross-sectional	To evaluate the mesial-distal position of the EFUPM, through panoramic and lateral cephalometric radiographs - Different anatomical tracings, one linear (mm), and eight angular measurements were performed and then compared between the two groups	24 Children aged 6-8 years: 12 with EFUPM 12 controls	NA	EFUPM can occur regardless of the skeletal pattern - The control group showed two significantly increased angular measurements: 6mx to palatal plane and 6mx to infraorbital plane; also, there is no direct relationship with the anteroposterior relationship of the apical bases - The ectopic group exhibited a significantly reduced mesial angulation, which represents a lack of space for the eruption of the first permanent molar

TABLE 3B Characteristics of the included studies (2011-2021).

first molar: A case report. J Dept Med Ser 2021;46:288-92.

- › Kim WS, Kim Y, Cho JH, Oh H, Hwang HS. Unlocking ectopically erupting permanent first molars using light wires. J Am Dent Assoc 2020;151:857-62.
- › Kimmel NA. Ectopic eruption of maxillary first permanent molars in different areas of the United States. ASDC J Dent Child 1982;49:294-9.
- › Kupietzky A. Correction of ectopic eruption of permanent molars utilizing the brass wire technique. Pediatr Dent 2000;22:408-12.
- › Kuroi J. Early treatment of tooth-eruption disturbances. Am J Orthod Dentofacial Orthop 2002;121:588-91.
- › Levac D, Colquhoun H, O'Brien KK. Scoping studies: Advancing the methodology. Implement Sci 2010;5:69-77.
- › Marra PM, Nucci L, Itrio A, Santoro R, Marra A, Perillo L, Grassia V. Prevalence of retained/transmigrated permanent and persistence of primary teeth associated with odontomas in young children. Eur J Paediatr Dent 2021;22:215-18.
- › Mitsuhashi C, Konishi Y, Kaihara Y, Kozai K. Treatment of ectopic eruption of permanent mandibular first molars with innovative dental appliances. Eur J Paediatr Dent 2014;15(2 Suppl):181-3.
- › Mooney GC, Morgan AG, Rodd HD, North S. Ectopic eruption of first permanent molars: A preliminary report of presenting features and associations. Eur Arch Paediatr Dent 2007;8:153-7.
- › Mubeen S, Seehra J. Failure of eruption of first permanent molar teeth: A diagnostic challenge. J Orthod 2018;45:129-34.
- › Mucedero M, Rozzi M, Cardoni G, Ricchiuti MS, Cozza P. Dentoskeletal features in individuals with ectopic eruption of the permanent maxillary first molar. Korean J Orthod 2015;45:190-7.
- › Nam OH, Ahn HJ, Kim MS, Park JH. Treatment of ectopic permanent maxillary first molar using a K-loop. J Clin Pediatr Dent 2015;39:387-91.
- › Nagaveni NB, Radhika NB. Interceptive orthodontic correction of ectopically erupting permanent maxillary first molar. A case report. Virtual J Orthod 2010. Available online at: <http://www.vjo.it/wp-content/uploads/2010/11/inter10.pdf>.
- › Romano FL, Arid J, Mussolino de Quiroz A, Bezerra-Segato RA, Nelson-Filho P. A modified Nance palatal arch for the treatment of ectopically erupting permanent first molars. J Dent Child 2016;83:161-6.
- › Salbach A, Schremmer B, Grabowski R, Stahl-de Castrillon F. Correlation between frequency of ectopic disorders for first permanent molars and the occurrence of malocclusions in early mixed dentition. J Orofac Orthop 2012;73:298-306.
- › Thakur S, Thakur N, Gupta S. Innovative chairside for the correction of ectopically erupting permanent first molar. Dent Hypotheses 2012;3:115-7.
- › Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for scoping reviews (PRISMA-ScR): Checklist and explanation. Ann Intern Med 2018;169:467-73.
- › Tripathi T, Singh N, Rai P, Khanna N. Separation and pain perception of Elastomeric, Kesling and Kansal separators. Dental Press J Orthod 2019;24:42-8.
- › Weinberger SJ. Correction of bilateral ectopic eruption of first permanent molars using a fixed appliance. Ped Dent 1992;14:382-3.
- › Yaseen SM, Naik S, Uloopi KS. Ectopic eruption – A review and case report. Contemp Clin Dent 2011;2:3-7.
- › Young DH. Ectopic eruption of permanent first molar. J Dent Child. 1957;24:153-62.