PREVALENCE AND SEVERITY OF ECTOPIC ERUPTION OF FIRST PERMANENT MOLARS IN 5 TO 12 YEAR OLD CHILDREN ATTENDING DUBAI DENTAL HOSPITAL IN UNITED ARAB EMIRATES.

Ali Mohammed Akbar
DDS, Ajman University, 2016

Submitted to the Hamdan Bin Mohammed College of Dental Medicine
Mohammed Bin Rashid University of Medicine and Health Sciences
in Partial Fulfillment of the Requirements for the Degree of
Master of Science in Pediatric Dentistry
2022

ABSTRACT

Prevalence and severity of ectopic eruption of first permanent molars in 5 to 12 year old children attending Dubai Dental Hospital in United Arab Emirates.

Ali Mohammed Akbar

Supervisors: Manal Al Halabi, Mawlood Kowash, Iyad Hussein, Anas Al Salami

Background: Ectopic eruption (EE) occurs when a tooth fails to follow its normal pathway of eruption. Failure to detect EE of a first permanent molar (FPM) can lead to premature loss of the second primary molar, loss of space available for the erupting premolar and complex treatment. It is usually diagnosed during radiographic examination in early mixed dentition. Selection of proper treatment option depends on the severity of EE.

Aim: The aim of the study was to investigate the patterns and severity of EE of FPM among 5- to 12-year-old children attending Dubai Dental Hospital (DDH).

Materials and Methods: This retrospective cross-sectional study was conducted using the dental records (radiographs and notes) of 962 patients (485 males, and 477 females) aged 5 to 12 years. The gender, age, nationality, and medical status of the patients, the tooth number, and severity of EE were recorded. The reported diagnosis of the EE of FPM in the patients' record and whether the patient was treated by a faculty member, or a postgraduate dentist were also recorded.

Results: Of the 962 patients, 39 (4.1%) patients had one of more EE of FPM. In those 39 patients, 61 ectopically erupting FPMs were reported. The distribution of EE of FPM showed significant difference between maxillary (2%) and mandibular (1.1%) FPMs (p-value=0.01334). Also, bilateral EE was 2.6 times more common in the maxillae than the mandible (p-value=0.013). Faculty members (8.3%) had reported significantly more ectopic eruptions of FPMs than training dentists (3.6%) (p-value=0.033).

Conclusions:

The prevalence of EE was within the range reported in previous studies.

DEDICATION

I am dedicating this thesis to my mother who helped me celebrate every success. To my mother who loved me unconditionally, and who encouraged and supported me during my times of weakness. You remain a beacon of light in dark times, a role model of faith, conscientiousness, and kindness.

I would like to thank my father, who supported me in every step, and taught me the value of hard work, consistency, and integrity.

My wife, Fatma, thank you for being so patient, and supportive during this journey.

DECLARATION

I declare that all the content of this thesis is my own work. There is no conflict of interest with any other entity or organization

Name: Ali Mohammed Akbar

Signature:

ACKNOWLEDGMENTS

I would like to thank my principal supervisor, Prof. Manal Al Halabi, without her support and guidance, this thesis could not have been completed. Her critical feedback, words of encouragement, and enthusiasm about the topic helped in keeping me inspired.

I would like to acknowledge my co-supervisors, Prof. Mawlood Kowash, Dr. Iyad Hussein, and Dr. Anas Al Salami. I thank you for your effort, support, and encouragement.

To my parents, siblings, and wife, and friends, your continued support, and encouragement cannot be thanked or explained in a simple paragraph.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

Ectopic eruption (EE) is a disturbance characterized by failing to follow the normal path of eruption. EE of the first permanent molar (FPM) is characterized by the eruption under the undercut of second primary molar and failure of the tooth to reach the occlusal plane due to being locked under second primary molar. (Chintaknon et al., 1998). Prevalence of EE of FPM varies among populations worldwide (Chintaknon et al. 1998; Kimmel et al., 1982; Guven, 2018). The lowest recorded prevalence rate was 0.75% and the highest was 6% with no significant differences between right and left, and between maxillary and mandibular arches. EE of FPM has been associated with dental and skeletal anomalies, canine impactions with increased prevalence between siblings (Chintaknon et al., 1998).

EE can be detected clinically or radiographically by failure of eruption of FPM (Barberia-Leache et al., 2005). It can also be diagnosed by pathological resorption of a root or roots of second primary molar noted during radiographic assessment (Barberia-Leache et al., 2005). Etiology of ectopic eruption of FPM is unknown; however, etiological factors include mesial deviation of eruption path of FPM, larger FPM, and lack of space due to growth deficiency in the posterior part of the mandible or maxilla (Chintaknon et al. 1998; Kimmel et al., 1982). Some cases might self-correct, however, if the FPM has failed to fully emerge by the age of seven, it is highly unlikely for it to self-correct, and intervention is required (Hennesy et al., 2012). The objective of the intervention is to move the ectopically erupting FPM away from the second primary molar and allow it to erupt in its normal position. If optimal position is not attained, the aim would be to allow the tooth to attain the best vertical position, with minimum loss of the arch space. (Barberia-Leache et al., 2005).

It is important to detect, intervene or follow up the ectopically erupting cases because it may lead to premature loss of primary second molar, or loss of space for the erupting second premolar or even its impaction (Chintaknon et al., 1998; Barberia-Leache et al., 2005).

Management of EE of first permanent molar depends on the severity of the case (Hennesey et al., 2012). EE can be subdivided into reversible and irreversible types (Barberia-Leache et al., 2005). The most recommended treatment options of the irreversible ectopic eruptions are extraction of second primary molar, disking of the distal side of the primary second molar, separation by elastic bands, the use of lingual arch with an auxiliary finger spring, and the use of a band on the second primary molar and a spring against first permanent molar.

The purpose of this study is investigating the pattern and severity of EE of FPMs in children aged 5 to 12 years old attending Dubai Dental Hospital (DDH) in United Arab Emirates (UAE) and compare it to the published worldwide patterns and severity ranges.

2. REVIEW OF THE LITERATURE

2.1 Normal Eruption Pattern

Tooth eruption is a crucial part of human development. In a human being, teeth vary in size, shape, and location in the jaw (Jain and Rathee, 2021). The variation in teeth shape, size and location in the mouth is essential for mastication, phonetics, and smiling (Hafiz, 2018). In addition, teeth offer a significant component of the dental and maxillofacial complex that helps shape the face accordingly (Kjaer, 2014). This is evident when comparing those adults with and without teeth. From birth, an individual has twenty primary teeth referred to as milk teeth, which usually start erupting progressively, on average, from the age of six-month (Marks and Shroeder, 1996). The American Academy of Pediatric Dentistry (AAPD) highlights that those primary teeth begin to shed from the age of six years and are replaced by permanent teeth. By the age of 21 years an adult human is expected to have 32 teeth (American Dental Association, 2020)

Tooth eruption is a complex process where teeth migrate from the mandibular or maxillary bones into the oral cavity (Chaitanya et al., 2018). The five phases of tooth eruption include pre-eruptive tooth movements, intraosseous stage, mucosal penetration, pre-occlusal and post occlusal stages (Jain and Rathee, 2021). Another categorization acknowledges three stages only: pre-eruptive movement, eruptive movement, and post-eruptive movement (Rabea, 2018). Pre-eruptive movement stage is shared in both primary and permanent dentition. This phase involves growth of the jaw, shifting of the gingiva due to the movement of teeth within the bone, and intra-alveolar modifications of the gingiva and mucosal tissues. This phase is important in positioning the tooth bud accordingly before the commencement of the eruptive phase (Jain and Rathee, 2021).

The eruptive phase involves movement of the tooth to its functional position in the jaw from its intraosseous place (Jain and Rathee, 2021). The eruptive movement involves the movement

of tooth from bone through the gingiva and to the oral cavity involving intraosseous penetration, mucosal penetration, intraosseous tissues, and supra-osseous tissues (Khan et al., 2020). The pre-occlusal phase entails the movement made by the tooth before reaching the functional occlusal location. It is important to note that the eruption of the teeth is influenced by environmental factors after emerging through the oral cavity (Sarrafpour et al., 2013). Some of the relevant environmental factors influencing teeth eruption include pressure of the buccal, labial, tongue muscles, as well as forces from adjacent teeth (Chapman, 1923). The post-occlusal movements help the tooth establish its functional position within the occlusal plane as per the growth of the maxilla or mandible, and compensatory tooth movement (Sarrafpour, 2013).

2.2 Theories of Tooth Eruption

Different subsequent researchers have accounted for the foundation behind tooth eruption identifying multiple theories. The first theory is the Cushioned Hammock Theory postulated by Hary Sicher (Jain and Rathee, 2021). The theory holds that tooth eruption is influenced by the cushioned hammock ligament which is usually located under the tooth (Jain and Rathee, 2021; Rabea, 2018). The second theory is the root formation theory which hypothesized that the eruption of the tooth is a reactive force to the pressure exerted by the roots of the teeth (Rabea, 2018). However, there is valid criticism for this theory with evidence indicating that the teeth continue to erupt even in the absence of root growth (Wang, 2013), other teeth erupt a height higher than the depth of the root (Marks and Shroeder, 1996).

Another theory is the vascular pressure theory, also referred to as the hydrostatic pressure theory. It explains the eruption because of increased fluid pressure from the dental pulp vessels and the periapical region (Sutton & Graze, 1985; Wise & King, 2008). The pressure is hypothesized to result in hydrodynamic and hydrostatic forces that push the tooth causing

eruption (Kjaer, 2014). Tooth eruption is also accounted for by the bone remodeling theory, which explains that osteoblasts and osteoclasts activities in the dental follicle lead to bone remodeling (Marks & Schroeder, 1996; Rabea, 2018). Two activities increase the resorption of the bone in the coronal area while also contributing to bone apposition around the apical region (Cowin & Hegedus, 1976; Hadjidakis & Androulakis, 2006). The reabsorption and apposition establish a pathway for passive tooth eruption (Rabea, 2018; Wise & King, 2008). In addition to the previous theories, the periodontal ligament traction theory which tries to explain tooth eruption because of eruptive forces originating from the fibroblast of the periodontal ligaments when they contract (Consolaro, 2012; Li et al., 2021; Oppenheim, 2007).

A newer theory, the bite forces theory, postulates that teeth eruption because of gingival adaptation to protect the soft tissue from biting forces. the biting forces trigger remodeling of the bonds through this development from the mandibular and maxillary bones (Oppenheim, 2007; Rabea, 2018). the last theory discussed in this section is the equilibrium theory (Lambrechts et al., 2010; Proffit, 1978; Rabea, 2018; Verdonck et al., 1993). According to its functional plane, further eruption occurs in response to the vertical growth of the lower jaw away from the maxilla (Lambrechts et al., 2010; Rabea, 2018). As a tooth gets more space, it erupts so closely to maintain or close the contact with the teeth in the opposing arch (Jain & Rathee, 2021; Rabea, 2018; Verdonck et al., 1993).

2.3 Overview of Ectopic Eruption of First Permanent Molar

Ectopic eruption is one of the physiological variations in teeth development (Khan et al., 2020). EE a disturbance characterized by failing to follow the normal path of eruption, it is characterized by the eruption under the undercut of the second primary molar that might lead to failure of the tooth to reach the occlusal plane due to being locked under second primary molar. The EE of FPM can be a reversible or irreversible problem (Güven, 2018). In reversible EE, the first permanent molar erupts into the oral cavity in the rightful functional position

within the occlusal plane. The reversible type of EE should be considered so only if there was any evidence of the deciduous molar root resorption (Güven, 2018; Hafiz, 2018). On the other hand, an irreversible EE refers to a situation where the tooth remains locked distally in the deciduous tissue (Mooney et al., 2007; Venere et al., 2021). The incidence is witnessed more among the male population as reported (Hafiz, 2018).

2.4 Etiology of Ectopic Eruption of First Permanent Molar

Previous scholars have evaluated the causing factors leading to the EE of teeth including first permanent molars. Small dental arches or large teeth, and lack of bony growth especially at the maxillary tuberosity area are some of the factors contributing to the EE (Venere et al., 2021). Also, an abnormal eruption route of FPM and premature eruption are significant etiological factors (Chintaknon & Boonpinon, 1998). It is also argued that the posterior position of the jaw in respect to the cranial base and the timing of calcification of the associated tooth are significant causes of EE (Venere et al., 2021). The occurrence of these factors could be due to genetic or environmental factors (Kjaer, 2014). In a study by Kaya et al., the morphological characteristics of the tooth position can experience deviation, especially with the space, due to factors such as hereditary issues, small jaws, early tooth extraction, retained primary teeth (Kaya et al., 2014). The characteristics of the jaw such as jaw size growth and osseous maturity can also be related to the EE (Larsen et al., 2010).

Ultimately, these causative factors might lead to EE, as described by one of the earliest studies to evaluate EE (Alami et al., 2019, Yaseen et al.,2011). The first cause was having small arch compromising the normal eruption of the tooth while the second was noted to be an attribution of abnormal path of the eruption of the permanent molar tooth. a third category entails a scenario where all the primary teeth failed to move forward impairing the development of the permanent teeth. the fourth main cause reported was when the eruption happens early before the expected timeline. in another study, the EE eruption was classified based on the

involvement of the teeth distal or proximal to the first permanent molar tooth. thereby leading to EE (Yaseen et al., 2011). Like other body organs, the timing and rate of growth of the teeth must be balanced for normal teeth eruption to happen (Chintaknon & Boonpinon, 1998). An imbalance resulting in abnormal tooth eruption could be attributed to environmental interferences, genetic factors, or physiological anomalies (Yaseen et al., 2011).

2.5 Prevalence of Ectopic Eruption of First Permanent Molars

The prevalence of EE of FPM varies across different areas and populations in the world. in a study assessing the prevalence of EE, the most prevalent eruption where those involving the canines or the first permanent molars (Marks & Schroeder, 1996). The prevalence of EE of first permanent molars Around the globe as reported in a study by Zou et al to be between 0.73% and 6% (Zou et al, 2018). In their study assessing EE of first permanent molar teeth in children in Thailand, Chintakanon reported prevalence of 0.75% in a sample of 4232 Thai children (Chintaknon & Boonpinon, 1998). A Study by Barberia-Leache et al. reported prevalence of 4.3% of the children with EE of FPM in Spanish children (Barberia-Leache et al., 2005). The prevalence of EE of maxillary FPM in Swedish sample of 2903 children was 4.3% (Bjerkin et al., 1995), while in Helm et al found a prevalence of 8.7% in a sample of 322 children in attending oral and maxillofacial radiology

center in Madrid, Spain. Mucedero et al study in Italy involving 1317 respondents, 2.5% of the participants had an ectopically erupted maxillary FPM (Mucedero et al., 1995).

Guven' study in Turkey involved 7,648 subjects reporting prevalence of 2.65% (Güven, 2018). while Aldowsari et. al found a prevalence of 2.2% in sample size of 2014 children in Saudia Arabia (Aldowsari et al, 2016). Meanwhile, a study by Jassim et. al. in Kuwait in 2010 found EE of FPM prevalence of 5.5% in a sample size of 213 children attending dental clinics in Kuwait university (Jassim et al, 2010)

The finding from Chintakanon showed that Thai males had a tendency for higher prevalence of FPM EE compared to females (Chintaknon & Boonpinon, 1998). Barberia-Leache et al. found no difference between boys and girls on the prevalence of EE of their first permanent molar (Barberia-Leache et al., 2005). They also noted that bilateral cases of EE of first permanent molar teeth were more common than unilateral, (63.6%, and 36.4% respectively) (Barberia-Leache et al., 2005). While in the Chintakanon study there was no difference based on the side of the EE, in the Guven study, the distribution was of the EE was more in the maxilla (57.5%) than the mandible (42.5%) (Chintaknon & Boonpinon, 1998, Güven, 2018).

2.6 Severity of Ectopic Eruption of First Permanent Molar

The diagnosis of EE of FPMs is determined based on a clinical evaluation and confirmed based on radiographic findings. according to the AAPD, notable findings for EE include missing the FPM, the emergence of the distal cusps, or distorted eruption of the molar (American Academy Pediatric Dentistry, 2011). Once diagnosed, the next phase is critical in devising the management of the problem is identifying the severity of the condition. the severity of EE is based on different criteria. the first is based on the width of the impacted ridge, which causes locks. a minimal lock involves a permanent molar being affected by at most half of the marginal ridge of the adjacent second molar (Dabbagh et al., 2017). A severe lock criterion is based on the magnitude of deciduous second molar resorption. in their study Barberia-Leache et al. and Hennessy et al. used this second parameter to categorize the severity of EE based on four grades shown in Table 1. (Mucedero et al., 2015, Hennessy et al., 2012)

Table 1 Describes the classification of ectopically erupting first permanent molars.

EE grade	**Severity**	**Effect on primary molar**
Grade 1	**Mild**	Limited resorption to the cementum or with minimum dentine penetration
Grade 2	**Moderate**	Resorption of the dentine without pulp exposure

Grade 3	**Severe**	Resorption of the distal root leading to pulp exposure
Grade 4	**Very Severe**	Resorption that affects the mesial root of the primary second molar

2.7 Management of Ectopic Eruption of FPM

The treatment and management of EE of FPM are essential. Up to 71% of the cases are reversible, observation and no treatment is the first option in young children with mild EE without signs and symptoms (Dabbagh et al., 2017). All irreversible or those qualified in the category of severe locks must be treated, otherwise, they may eliminate space for the developing permanent premolars. the severe locks can also cause malocclusion, and decreased arch length (Oppenheim, 2007). early diagnosis of EE is essential for the delivery of appropriate treatment. the choice of treatment for severe EE is dependent on several factors. the first factor is the patient's age, where a six month follow up is recommended to monitor for self-correction (Hennessy et al., 2012). However, when self-correction does not take place, interceptive treatment should commence as soon as possible to prevent resorption of primary second molar (Hafiz, 2018). The second factor considered is the status of the second primary molar since it influences determining whether to extract the tooth and use space maintainers to hold the space. the third factor is the presence of second premolar which according to Mucedero et al. influences the decision to extract the primary second molar to allow the first permanent tooth to drift mesially (Mucedero et al., 2015). The fourth consideration is the severity of the impaction, which can help determine the most appropriate corrective measure. as aforementioned, those aged below six years should be observed for six months to assess for self-correction, which would not need any further treatment. Most cases with spontaneous self-

correction occur before the age of seven (Yaseen et al., 2011), however, where treatment is needed the available options include:

2.7.1 Using Orthodontic Interproximal Separators

Interproximal washing involves placing the separating in. between the first permanent molar and second primary molar. precautions should be taken to avoid inducing infection to the second primary molar tooth (Yaseen et al., 2011) some of the separators used include an elastomeric separator, Kesling separator and brass wire. the use of an elastomeric separator is associated with a high risk of apical separation, which can lead to periodontal irritation (Hennessy et al., 2012). a brass wire is highly recommended in cases where only a small amount of movement is needed with minimal visibility of the mesial surface of the first permanent molar. However, the use of the brass wire may involve the use of anesthesia. orthodontic separators were successfully used in a case by Seehra et al. reporting satisfactory disimpaction leading to normal vertical eruption and art length preservation (Seehra et al., 2011).

2.7.2 Distal Tipping

It is essential in cases where there is severe resorption of the primary molar and with the drifting mesially of the permanent molar. the first alternative in distal tipping involves the use of the transpalatal atch with distal hook (Hennessy et al., 2012). the process involves fabricating a transpalatal arch (TPA) on the primary molars with a cantilever arm stretching the arch distally. using the established hook can be used to attach an elastomeric band or spring to the cantilever arm and bonding that was the permanent molar (Seehra et al., 2011). By doing so, flexion force is exerted causing distal movement of the ectopic tooth. the second alternative is the use of a fixed appliance. A TPA is fixed on the primary molars seeking to create a stable anchor to

support a bracket position at the buccal surface of the permanent molar (Hennessy et al., 2012). Another option is Halterman-type appliance, which are used to aid in both of correction of ectopic and regaining space. If a Halterman-type appliance is planned, a thorough examination including the age of the patient, the amount of space lost, the dentofacial features of the patient and an orthodontic consultation is required (American Academy of Paediatric. Dentistry, 2021)

2.7.3 Surgical Intervention

Surgical correction is rarely used, unless when detected in late life with surgery (Mucedero et al., 2015). Inability to correct the EE early would increase the chances of complex surgical procedures such as extraction of second primary molar or using surgical exposure and the placement of elastic separators (Aldowsari et al., 2021).

3. AIM

Investigate the prevalence and severity of EE of FPMs among 5 to 12 year-old children attended Dubai Dental Hospital in the UAE.

3.1 Specific Objectives

1. Compare the prevalence and severity of EE of FPM between males and females.
2. Compare the prevalence and severity of EE of FPM between 5-8- and 9–12-year-old patients
3. Compare the EE prevalence and severity between Healthy and medically compromised patients
4. Compare the EE prevalence and severity between maxilla and mandible
5. Compare the EE prevalence and severity between right and left side

3.2 Hypothesis

Prevalence and severity of EE of FPM among children attending Dubai dental hospital in United Arab Emirates is within the reported worldwide range.

4. MATERIALS AND METHODS

The proposed study is of a retrospective cross-sectional design, which study aim is to investigate the patterns and severity of EE of FPM among children attended DDH in the UAE. Dental records including radiographs of children aged 5 to 12 years were reviewed. EE of FPM was recorded and graded according to the radiographs.

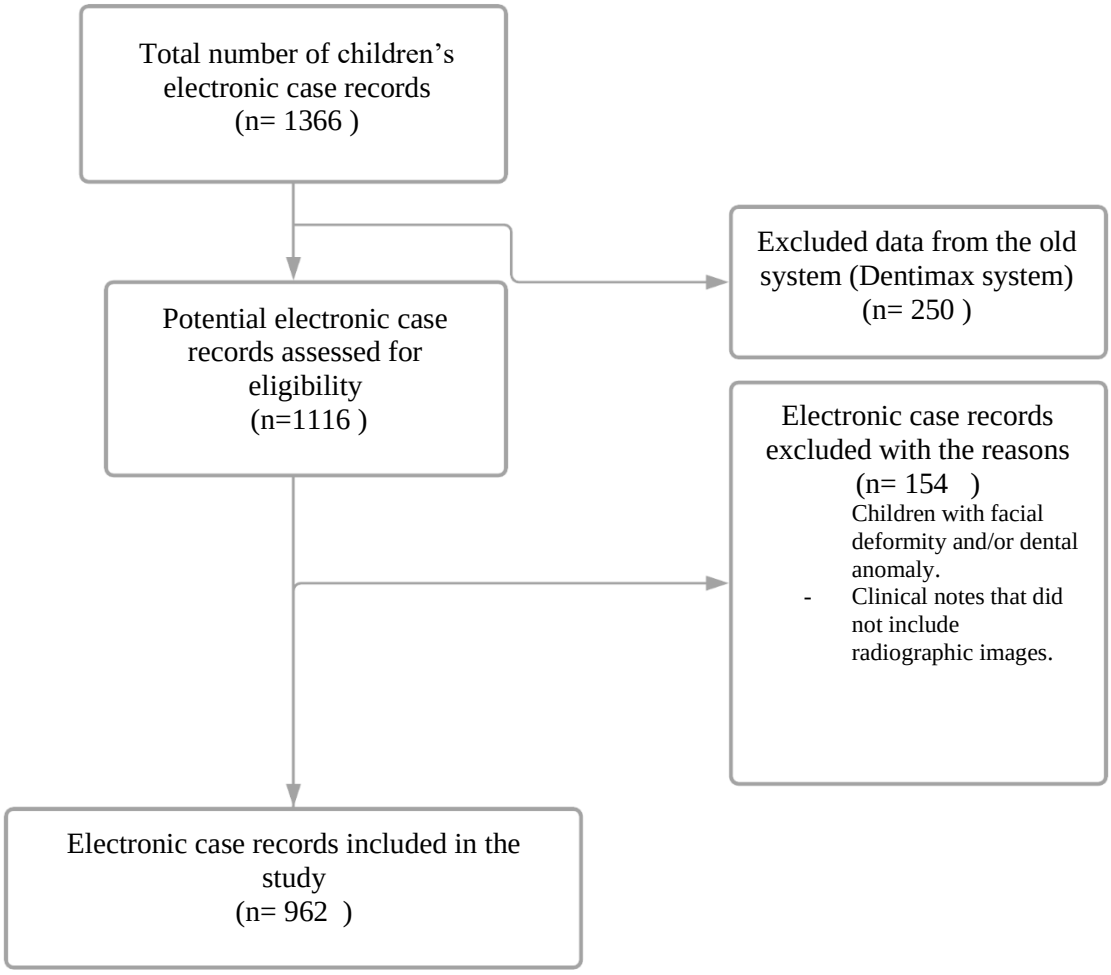
4.1 Inclusion Criteria

All electronic dental notes of children aged 5-12 years who attended DDH due to their need of dental treatment or regular dental checkups during the period between June 1st, 2016-February 29th, 2020. The data were collected by accessing the digital clinical notes in DDH, that were stored in the Dental4Windows™ (D4W) system. Complete electronic dental notes with complete dental charting and periapical (PA) bitewing and orthopantomogrph (OPG) radiographic images showing the mesial aspects of one or more of the four FPMs as well as the second primary molar. Both "jumped" and "hold" cases were included.

4.2 Exclusion Criteria

Clinical notes of patients with dental and/or craniofacial anomalies. Also, patient files that did not include radiographic images were excluded from this study. All patient records registered the previously used and outdated system of DDH (Dentimax®) were excluded because of difficulty in accessing the files and retrieving the radiographs. This system was in operation prior to June 2016. Radiographic images that did not show the second primary molars or where the second primary molar was extracted or exfoliated were excluded.

Figure 1: Flow-chart showing the process of data extraction



4.3 Calibration and Reliability

Calibration of randomly selected 13 intraoral bitewing and periapical radiographs were separately assessed twice by the two assessors (MM and AA) at a 2-week period for intra and inter-examiner reliability. The results of Kappa score were 0.806 with $p < 0.05$ (for MM Intra-calibration), 0.755 (for AA Intra-calibration) and 0.806 for the inter-calibration analysis between MM & AA. Cases were divided between the assessors according to the file number. MM and AA assessed the independent notes, all the radiographs were examined using the same screen resolution, with the same brightness.

4.4 Pilot study

A pilot study including 10 randomly selected bitewing radiographs was conducted prior to starting the data collection process. Modification to the data collection sheet were made accordingly.

4.5 Sample Size

A convenience sample of all children's electronic records that met the inclusion criteria (n=1116) between June 1st 2016 – February 29th 2020, were included in the study.

4.6 Data Collection

The data was collected by accessing the digital patient record system (D4W) of the Pediatric Dentistry Department at DDH. The following data were collected by the principal investigator (AA) and an assessor (MA) using a Microsoft Excel standard proforma (Appendices 1 and 2).

4.7 Patient Demographics

The sample's demographic characteristics were age in years, gender, nationality (from UAE or other countries) and the general health (healthy, special needs and/or medically compromised).

4.7.1 First Permanent Molar Ectopic Eruption Clinical Data

FPMs clinical eruption status was collected and assessed from the included patients' available chart and clinical notes by recording which of the first permanent molar/s is/are affected.

4.7.2 First Permanent Molar Ectopic Eruption Radiographic Data

The recorded clinical status of the eruption of FPMs data were reviewed from the radiographic images (BW, PA, OPG) in the D4W. In addition to grading the severity of EE if present using radiographs as reported by Hennessey et al. (Appendix 3) into the following:

Grade 1 (Mild): Limited resorption to the cementum or with minimum dentine penetration

Grade 2 (Moderate): Resorption of the dentine without pulp exposure

Grade 3 (Severe): Resorption of the distal root leading to pulp exposure

Grade 4 (Very Severe): Resorption that affects the mesial root of the primary second molar.

In cases with multiple radiographs during multiple visits, the most severe finding was recorded.

4.8 Statistical Analysis

Data was entered in computer using IBM-SPSS for Windows version 28.0 (SPSS Inc., Chicago, IL). The Chi-squared test or Fisher's exact test were used to investigate association of categorical data. Kappa score test was used to assess agreement level in inter- and intra-examiner calibration.

4.9 Ethical Consideration

The ethical approval was obtained from the Research Ethics Review Committee at Mohammed Bin Rashid University of Medicine and Health Sciences (MBRU) (Appendix 4, RE: MBRU-IRB-2020-037, approved September 29th, 2020). The patients' names were kept anonymous to protect their privacy and confidentiality.

5. RESULTS

5.1 Demographical characteristics of the sample study

A total of 962 patients met the inclusion criteria in this study, of which 485 (50.4%) were males, and 477 (49.6%) were females. Ages of the sample patients ranged between 5 and 12 years with a mean age of 7.99(±2.2) years. According to nationality, 317 (33%) were from UAE and 645 (67%) were from other nationalities. Among the 962 examined patients, 866 (90%) patients were medically fit and healthy, and 96 (10%) were special needs and/or medically compromised children, and were recorded as having asthma, autism, attention deficit hyperactivity disorder (ADHD), liver disease, kidney disease, congenital heart disease, iron deficiency anaemia, sickle cell anaemia, cerebral palsy, coeliac disease, glucose-6-phosphate dehydrogenase (G6PD) anaemia, thalassemia and kawasaki disease. The demographic characteristics of included patients are summarized in Table 1.

Table 1: Demographical characteristics of study sample

Items	No. (%)
Gender	
Male	485 (50.4)
Female	477 (49.6)
Nationality	
UAE	317 (33)
Expatriate	645 (67)
Medical Status	
Healthy	866 (90)
Patient with medical issue	96 (10)
Age	
5-8 years	579 (60.2)
9-12 years	383 (39.8)

5.2 Prevalence of Ectopic Eruption in the study sample per tooth

A total of 3808 FPMs were examined radiographically for the presence of ectopic eruption among available periapical, orthopantomograph (OPG) and bitewing radiographs. The total number of ectopically erupting FPMs in 39 patients was 61 teeth which accounts for 1.6%. In the maxillary arch, the upper right FPMs, 21 (2.2%) of 950 teeth were recorded as ectopically erupted of which seven cases were grade 1, five cases were grade 2, five cases were grade 3, and four cases were grade 4. On the other side, for upper left FPM, 19 (2%) of the 956 teeth were recorded as ectopically erupted of which seven cases were recorded as grade 1, seven cases grade 2, four cases grade 3, and one case grade 4. As for the mandibular arch, the lower left FPM had 11 (1.2%) of 950 examined teeth were recorded as ectopically erupted of which eight cases were grade 1, two cases grade 2, and one case grade 3, and for the lower right FPM, 10 teeth (1.1%) of 952 examined teeth were recorded as ectopically erupted of which seven cases were grade 1, one case grade 2, one case grade 3, and one case grade 4.

Distribution of grades of ectopic eruption of FPMs per tooth and location are presented in tables 2, 3 and 4.

Table 2 Distribution of grades of ectopic eruption of FPM per tooth

Tooth	Upper right first permanent molar (Tooth #16)	Upper left first permanent molar (Tooth #26)	Lower left first permanent molar (Tooth #36)	Lower right first permanent molar (Tooth #46)
Grades n (%)	***n (%)***	***n (%)***	***n (%)***	***n (%)***
No	929 (97.8)	937 (98)	939 (98.8)	942 (98.9)
Grade 1	7 (0.7)	7 (0.7)	8 (0.8)	7 (0.7)
Grade 2	5 (0.5)	7 (0.7)	2 (0.2)	1 (0.1)
Grade 3	5 (0.5)	4 (0.4)	1 (0.1)	1 (0.1)
Grade 4	4 (0.4)	1 (0.1)	0 (0)	1 (0.1)
Percentage of ectopic eruption per tooth (%)	2.2%	2%	1.2%	1.1%

Table 3 Distribution of grades of ectopic eruption of maxillary and mandibular FPM per tooth

Tooth	Maxillary FPMs	Mandibular FPMs	P-value*
Total number of teeth examined n (%)	1906	1902	
No	1866 (98)	1881 (98.9)	0.013338
Grade 1	14 (0.7)	15 (0.79)	
Grade 2	12 (0.6)	3 (0.15)	
Grade 3	9 (0.5)	2 (0.11)	
Grade 4	5 (0.3)	1 (0.05)	
Total number of ectopic eruptions per arch	40 (2)	21 (1.1)	

Table 4 Distribution of grades of ectopic eruption of right and left FPM per tooth

Tooth	Right FPMs (#16, #46)	Left FPMs (26, 36)	P-value*
Total number of teeth examined n (%)	1902	1906	
No	1871 (98.3)	1876 (98.4)	0.494095
Grade 1	14 (0.7)	15 (0.9)	
Grade 2	6 (0.3)	9 (0.5)	
Grade 3	6 (0.3)	5 (0.3)	
Grade 4	5 (0.3)	1 (0.05)	
Total number of ectopic eruptions per side	31 (1.6)	30 (1.6)	

5.3 Prevalence of Ectopic Eruption in the study sample per patient

The prevalence of EE of FPMs in the studied sample was 39 (4.1%). The most affected tooth was the upper right FPM. In Figure 1, although more males had EE of FPM than females (Table 5), the difference was not statistically significant (P-value=0.274). The percentage of patients displaying ectopic eruption among the UAE patients (4.4%) was higher than non-UAE patients (3.9%) (Table 5). However, the difference was not statistically significant (P-value=0.404). Patients with medical conditions other than the excluded ones had more EE (Table 5) than healthy individuals. However, the difference was not statistically significant (p-value=0.337).

5.4 Comparison of the prevalence of ectopic eruption of FPMs between dental arches.

The maxillary FPMs were 2.6 times more likely to display bilateral EE compared to the mandibular FPM. This difference was statistically significant (p-value=0.013). However, unilateral maxillary and mandibular EE showed no statistically significant difference (p-value=0.9116) as shown in Table 6. Also, as presented in Table 3, the percentage of EE of FPMs was significantly higher in the maxillary arch when compared to the mandibular arch (p-value=0.01334)

Figure 2 Distribution of severity of ectopic per tooth and gender

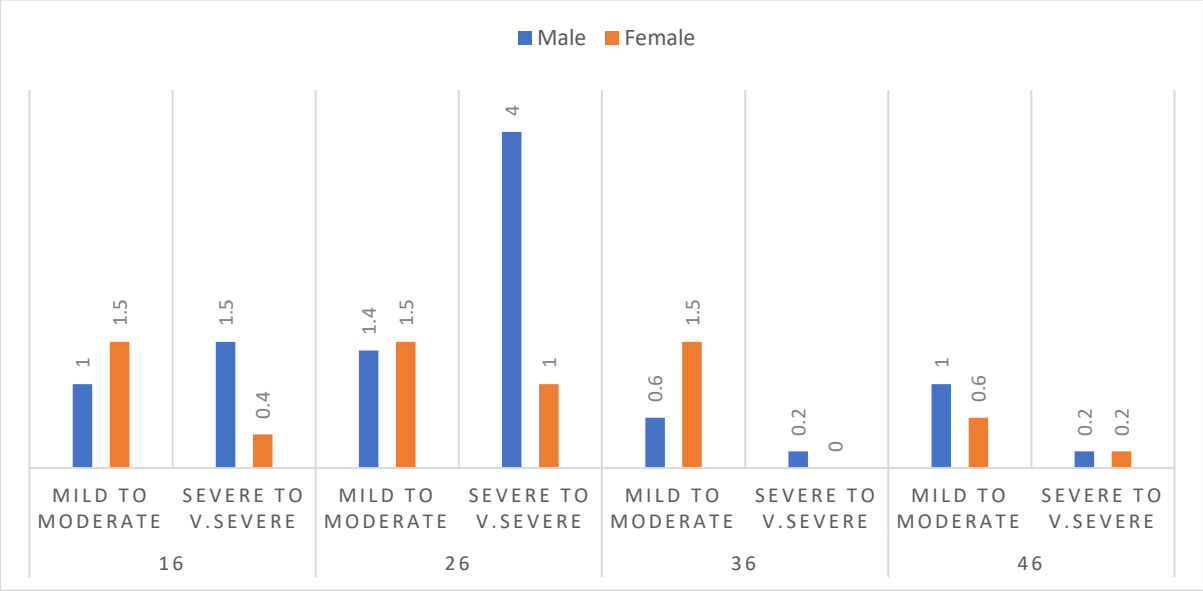


Table 5 Comparison of EE of teeth in the study sample per patient by demographical data

study sample	Examined patients without ectopic eruption	patients with ectopic eruption	P-value#
Total number of patients (962)	923	39	
Gender			
Male	463 (95.5)	22 (4.5)	
Female	460 (96.4)	17 (3.6)	0.274
Nationality			
UAE	303 (95.6)	14 (4.4)	
Non-UAE	620 (96.1)	25 (3.9)	0.404
Medical Status			
Healthy	789 (96.1)	32 (3.9)	
Patient with medical conditions	133 (95)	7 (5)	0.337
Age			
5 – 8 years	560 (96.6)	20 (3.4)	
9 – 12 years	363 (95)	19 (5)	0.093

*Statistically significant.

Table 6 Comparison of unilateral and bilateral EE in the study sample in maxillary and mandibular arches per patient.

	Mandibular FPM	Maxillary FPM	P-value
	n (%)		
Ectopic eruption			
No ectopic eruption	940 (98.4)	932 (97)	
Unilateral	11 (1.1)	16 (1.7)	0.9116
Bilateral	5 (0.5)	12 (1.3)	0.013*

*Statistically significant

5.5 Severity of Ectopic Eruption per patient

Female patients had a tendency for more severe to very severe cases of EE compared to male patients, this difference was not statistically significant with P-value of 0.067. Also, Emirati patients had more grade 3 and grade 4 EE (71.4%) compared to non-UAE patient's (64%), this difference was not statistically significant as well with p-value of 0.458. (Table 7)

Furthermore, no statistically significant difference was found in terms of severity of EE in relation to different age groups (5–8-year-old patients and 9–12-year-old patients) (p-values 0.545 and 0.093) respectively as shown in Table 7. The difference in severity between healthy patients and patients with medical issues was not statistically significant (P-value 0.456).

Table 7 Comparison of severity of EE by demographical data

Items	Grade 1 & 2 Nr (%)	Grade 3 & 4 Nr (%)	P-value*
Gender			
Male	10 (45.5)	12 (54.5)	
Female	3 (17.6)	14 (82.4)	0.067
Nationality			
UAE	4 (28.6)	10 (71.4)	
Expatriate	9 (36)	16 (64)	0.458
Medical Status			
Healthy	11 (35.5)	20 (64.5)	

Patient with medical issue	2 (25)	6 (75)	0.456
Age			
5 – 8 years	6 (31.6)	13 (68.4)	0.545
9 – 12 years	7 (35)	13 (65)	

6. DISCUSSION

Ectopic eruption of first permanent molars FPMs can be diagnosed early by proper clinical and radiographic examination (Helm et. al., 2021). To the best of our knowledge, this is the first study conducted in the UAE to assess the prevalence and severity of EE of FPMs.

The prevalence of EE in this study was 4.1% per patient which was within the prevalence range reported across countries in previous studies which is 0.7%-8.7% (Elsayed et al., 2020; Chintaknon & Boonpinon, 1998; Aldowsari et al., 2021; Yassin et al., 2016; Bjerklin et al., 1995; Guven, 2018; Mucedero et al., 1995; Barberia-Leache et al., 2005, Jassim et. al, 2010; Helm et al., 2021). The wide range and increased variability in prevalence of EE can be attributed to examination methods, assessment criteria, inclusion criteria, types of radiographs used, and age in included samples (Chinankton, 1998). Some studies suggested the association between increased prevalence of EE and presence of dental anomalies (Baccetti, T., 1998). Patients with history of dental anomalies were excluded from our study. Some studies included patients from 6 to 9 years old, while the included age range in this study is from 5 to 12 years old children (Barberia-Leache et al., 2005).

The severity and pattern of EE of FPM were assessed radiographically for 962 patients. Inter- and intra-examiner test for detecting and assessing the severity of EE were conducted to reduce the risk of bias and assess reliability.

The overall prevalence in this study was higher compared to studies in nearby Gulf Cooperation Council (GCC countries). In the Kingdom of Saudi Arabia (KSA), Yassin in Abha region in 2016, Aldowsari in Riyadh in 2021, and Elsayed et. al. in Almadina Almuwarrah in 2016, reported 2.3%, 2.2% and 0.7% respectively. However, our reported prevalence was lower than

the percentage reported in Kuwait including 6–9-year-old patients which was 5.5% (Jassim et. al, 2010).

The reported value of EE of FPMs in this study was also higher than the reported value in Turkish population, Thai population, and Italian population which were 2.65%, 0.75%, and 2.5%, respectively (Guven, 2018; Chintaknon & Boonpinon, 1998; Mucedero et al., 1995). This might be attributed to differences in ethnicity, genetic background, or difference in sample size and inclusion criteria. Also, the reported value in the current study was lower than the reported values in Spanish children (8.7%), and Swedish population (4.3%) (Helm et al., 2021, Bjerklin et al., 1995). The prevalence reported by Helm et al., in Spanish children attending maxillofacial radiology center in Madrid, Spain (8.7%) was more than double the percentage reported in the current study and was around double the percentage reported by Barberia-Leache et al. in Spanish children (4.3%). This might be attributed to the inclusion criteria and the oral and maxillofacial radiology center the study was conducted in (Helm et al., 2021; Barberia-Leache et al., 2005).

In the current study, the frequency of EE of FPMs in boys was higher than girls. This is similar to the findings in Thai population, and two studies conducted in Turkish population (Chintaknon & Boonpinon, 1998; Guven, 2018; Caliskan et al., 2021). It is also in agreement with the findings in reported results for Saudi children in Riyadh and Abha populations (Aldowsari et al., 2021; Yassin et al, 2016).

The findings in the current study were also in line with the finding of two other previous studies of O'Meara and Sun et. al. where they found unilateral EE of FPM more frequent than bilateral (O'Meara, 1962; Sun et al. 2016). Sweet, and Helm et al. reported a higher frequency of bilateral EE than unilateral EE of FPM in two separate studies, which was contrary to the findings in this study (Sweet, 1939; Helm et al., 2021). The aforementioned results agreed with

the findings in Spanish population (Barberia-Leache et al., 2005). Moreover, studies in Thai and Turkish populations showed no difference between the frequency of unilateral and bilateral EE FPM(Chintakanon & Boonpinon, 1998; Guven, 2018). A Study in Spanish population found that children with bilateral EE of maxillary FPMs had a more posterior position of upper incisors, and decreased palatal plane values (Helm et al., 2021).

In the current study, the proportion of EE of FPMs in the maxillary arch was higher than the mandible similar to the findings of other previous studies in KSA, Turkey, Thailand, and England (Aldowsari et al., 2016; Salbach et al. 2012, Chintakanon et al., 2018, Mooney et al., 2005). However, Guven's study in Turkish population found no difference in frequency of EE between maxilla and mandible (Guven, 2018). The higher prevalence of EE in the maxilla might be attributed to the anatomical and morphological differences between the maxilla and the mandible. Some of the maxillary factors that were associated in patients with EE of maxillary FPMs are shortened anterior cranial base, more distal position of the maxillary FPM in relation to pterygoid vertical, and retrognathic maxilla (Helm et al., 2021).

Also, previous studies reported no difference in the frequency of EE of FPMs between right and left side (Aldowsari et al., 2016; Guven, 2018; Mooney et al., 2005). However, a study in Korea reported a higher frequency of ectopic FPMs on the right side (59.3%) than the left side (Sun et al., 2016).

Similar to the findings of previous studies by Aldowsari et al., and Salbach et al., the current study found no relationship between the EE of FPMs with age, gender, or nationality (Aldowsari et al., 2016; Salbach et al., 2012). However, this was not consistent with the findings of Sun et al., and Caliskan et al. (Sun et al., 2016; Caliskan et al., 2021).

EE of FPMs is defined as a situation in which the permanent tooth deviates from its eruptive pathway. In such cases, the tooth will erupt in the mouth in a position different than it should or becomes totally blocked out of eruption. In both situations, it often causes damage to the roots of the adjacent second primary molar (Proffit et al., 2019). The severity of EE is a major factor to determine the treatment plan. In the current study, the condition of EE was more severe in the maxilla compared to the mandible which is consistent with the finding of previous studies in Thai population and Turkish population (Chintakanon & Boonpinon, 1998; Guven, 2018). Chintakanon and Boonpinon reported that most of EE occur in the maxilla, the crown of FPM is usually impacted on the cementoenamel junction (CEJ) which leads to greater resorption. Also, in this study, the most frequent type of EE was the mild type. This is in consistent with the previous studies in Saudi, Turkish and Spanish populations (Aldowsari et al., 2016; Guven, 2018, Barberia-Leache et al., 2005).

Limitations of this study include the fact that it had a retrospective design which depends on the quality and type of radiographs available. Additionally, the age of patients was recorded in years only rather than months, which may have altered the exact age in which EE was diagnosed. Another drawback of the current study was that the findings were from one dental hospital in Dubai, UAE. Future studies should consider multi-center design across all of the UAE's seven Emirates. Despite the fact that the prevalence of EE (4.1%) in this study was within the prevalence range reported across countries in previous studies, it might not be reflecting the prevalence of FPMs EE of the UAE general population

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusion

In children aged between 5- 12 years of age who attended DDH between 2016 and 2020 and within the limitation of this study, we can conclude:

- The prevalence of EE was 4.1% which was within the reported range in other studies in the region and globally.
- There was no significant difference between male and female patients, different age groups, patients' that are healthy and patients with medical conditions and between right and left sides in the prevalence and severity of EE.
- EE FPMs were significantly more frequent in the maxilla compared to the mandible, and a tendency for more severe cases were reported in the maxilla.
- Bilateral EEs of FPMs were significantly more frequent in the maxilla than the mandible

7.2 Recommendations

The results of this study suggested that more emphasis and effort should be exerted to increase awareness and educate dental professionals regarding the early detection, diagnosis, and management of EE from as early as 5-year-old patients. Also, Future studies to investigate presenting features of ectopically erupting first permanent molars and associations with other dental anomalies.

8. REFERENCES

Aldowsari, M., Alsaidan, M., Alaqil, M., BinAjian, A., Albeialy, J., Alraawi, M. and Al Moaleem, M., 2021. Ectopic Eruption of First Permanent Molars for Pediatric Patients Attended King Saud University, Riyadh, Saudi Arabia: A Radiographic Study. *Clinical, Cosmetic and Investigational Dentistry*, Volume 13, pp.325-333.

American Academy Pediatric Dentistry, 2021. Official but Unformatted Management of the Developing Dentition and Occlusion in Pediatric Dentistry.

Baccetti, T., 1998. A controlled study of associated dental anomalies. *Angle Orthod*, 68(68), pp.267-274.

Barberia-Leache and Elena, 2005. Ectopic Eruption of the Maxillary First Permanent Molar: Characteristics and Occurrence in Growing Children. *The Angel Orthodontist*, 75(4), pp.610 - 615.

Bjerklin, K. and Kurol, J., 1983. Ectopic eruption of the maxillary first permanent molar: Etiologic factors. *American Journal of Orthodontics*, 84(2), pp.147-155.

Bjerklin, K., Gleerup, A. and Kurol, J., 1995. Long-term treatment effects in children with ectopic eruption of the maxillary first permanent molars. *The European Journal of Orthodontics*, 17(4), pp.293-304.

Bondemark, L. and Tsiopa, J., 2007. Prevalence of Ectopic Eruption, Impaction, Retention and Agenesis of the Permanent Second Molar. *The Angle Orthodontist*, 77(5), pp.773-778.

Caliskan, S., Tuloglu, N., Ozdemir, C., Kizilaslan, S. and Bayrak, S., 2020. Ectopic eruption of maxillary permanent first molars: Predictive factors for self-corrected and impacted outcome. *International Journal of Clinical Practice*, 75(3).

Chaitanya, P., Reddy, J., Suhasini, K., Chandrika, I. and Praveen, D., 2018. Time and Eruption Sequence of Permanent Teeth in Hyderabad Children: A Descriptive Cross-sectional Study. *International Journal of Clinical Pediatric Dentistry*, 11(4), pp.330-337.

Chapman, H., 1923. First upper permanent molars partially impacted against second deciduous molars. *International Journal of Orthodontia, Oral Surgery and Radiography*, 9(5), pp.339-345.

Chintakanon, K. and Boonpinon, P., 1998. Ectopic eruption of the first permanent molars: Prevalence and etiologic factors. *Angle Orthod*, 68, pp.153-60.

Consolaro, A., 2012. Induced tooth movement: standardization of terms to describe the effects of forces on the periodontal ligament: compression/Traction instead of Pressure/Tension. *Dental Press Journal of Orthodontics*, 17(2), pp.27-29.

Cowin, S. and Hegedus, D., 1976. Bone remodeling I: theory of adaptive elasticity. *Journal of Elasticity*, 6(3), pp.313-326.

Dabbagh and Basma, 2017. Ectopic Eruption of the Permanent Maxillary First Molar: Predictive Factors for Irreversible Outcome. *Pediatric Dentistry*, 39(3), pp.215-218.

Di Venere, D., Laforgia, A., Lorusso, P., Capodiferro, S. and Corsalini, M., 2021. Ectopic Eruption of the First Permanent Molar in the Maxilla: Cephalometric Features of 13 Pediatric Patients. *Applied Sciences*, 11(17), p.7869.

Elsayed, S., Althagafi, N., Bahabri, R., Alshanqiti, M., Alrehaili, A. and Alahmadi, A., 2020. Retrospective Radiographic Survey of Unconventional Ectopic Impacted Teeth in Al-Madinah Al-Munawwarah, Saudi Arabia. *Open Access Macedonian Journal of Medical Sciences*, 8(D), pp.203-208.

Güven, Y., 2018. Prevalence of ectopic eruption of first permanent molars in a Turkish population. *European Oral Research*, 52(1), pp.1-5.

Hadjidakis, D. and Androulakis, I., 2006. Bone Remodeling. *Annals of the New York Academy of Sciences*, 1092(1), pp.385-396.

Hafiz, Z., 2018. Ectopic eruption of the maxillary first permanent molar: a review and case report. *Journal of Dental Health, Oral Disorders & Therapy*, 9(2).

Hennessy, J., Al-Awadhi, E., Dwyer, L. and Leith, R., 2012. Treatment of ectopic first permanent molar teeth. *Dental Update*, 39(9), pp.656-661.

Jain, P. and Rathee, M., 2021. *Anatomy, Head and Neck, Tooth Eruption*. NCBI.

Jassim, A., Froughi, E. and Alsane, M., 2010. Ectopic Eruptions of First Permanent Molars: Prevalence and Characteristics.

Kaya, G., Muzaffer, M., Omezli, M. and Dayi, E., 2010. Some morphological features related to mandibular third molar impaction. *Journal of Clinical and Experimental Dentistry*, pp.e12-e17.

Kimmel, N., Gellin, M., Bohannan, H. and Kaplan, A., 1982. Ectopic eruption of maxillary first permanent molars in different areas of the United States. *ASDC J Dent Child.*, 49(4), pp.294-9.

Kjær, I., 2014. Mechanism of Human Tooth Eruption: Review Article Including a New Theory for Future Studies on the Eruption Process. *Scientifica*, 2014, pp.1-13.

Lambrechts, H., De Baets, E., Fieuws, S. and Willems, G., 2010. Lip and tongue pressure in orthodontic patients. *The European Journal of Orthodontics*, 32(4), pp.466-471.

Larsen, H., SÃ¸rensen, H., Artmann, L., Christensen, I. and KjÃ¦r, I., 2010. Sagittal, vertical and transversal dimensions of the maxillary complex in patients with ectopic maxillary canines. *Orthodontics & Craniofacial Research*, 13(1), pp.34-39.

Li, Y., Zhan, Q., Bao, M., Yi, J. and Li, Y., 2021. Biomechanical and biological responses of periodontium in orthodontic tooth movement: up-date in a new decade. *International Journal of Oral Science*, 13(1).

Marks, S. and Schroeder, H., 1996. Tooth eruption: Theories and facts. *The Anatomical Record*, 245(2), pp.374-393.

Mooney, G., Morgan, A., Rodd, H. and North, S., 2007. Ectopic eruption of first permanent molars: A preliminary report of presenting features and associations. *European Archives of Paediatric Dentistry*, 8(3), pp.153-157.

Mucedero, M., Rozzi, M., Cardoni, G., Ricchiuti, M. and Cozza, P., 2015. Dentoskeletal features in individuals with ectopic eruption of the permanent maxillary first molar. *The Korean Journal of Orthodontics*, 45(4), p.190.

O'Meara, W., 1962. Ectopic Eruption Pattern in Selected Permanent Teeth. *Journal of Dental Research*, 41(3), pp.607-616.

Oppenheim, A., 2007. Tissue changes, particularly of the bone, incident to tooth movement. *The European Journal of Orthodontics*, 29(Supplement 1), pp.i2-i15.

Proffit, W., 1978. Equilibrium Theory Revisited: Factors Influencing Position of the Teeth. *Angel Orthod*, 48, pp.175-86.

Proffit, W., Fields, H., Larson, B. and Sarver, D., 2019. *Contemporary Orthodontics*. 6th ed. St. Louis: Mosby, pp.377-78.

Rabea, A., 2018. Recent advances in understanding theories of eruption (evidence based review article). *Future Dental Journal*, 4(2), pp.189-196.

Ragini, Singh, N., Goyal, S., Padmanabhan, P. and Munjal, P., 2003. Prediction of Third Molar Eruption. *Journal of Indian Orthodontic Society*, 37(2), pp.103-112.

Salbach, A., Schremmer, B., Grabowski, R. and Stahl de Castrillon, F., 2012. Correlation between the frequency of eruption disorders for first permanent molars and the occurrence of malocclusions in early mixed dentition. *Journal of Orofacial Orthopedics / Fortschritte der Kieferorthopädie*, 73(4), pp.298-306.

Sarrafpour, B., Swain, M., Li, Q. and Zoellner, H., 2013. Tooth Eruption Results from Bone Remodelling Driven by Bite Forces Sensed by Soft Tissue Dental Follicles: A Finite Element Analysis. *PLoS ONE*, 8(3), p.e58803.

Seehra, J., Winchester, L., DiBiase, A. and Cobourne, M., 2011. Orthodontic management of ectopic maxillary first permanent molars: a case report. *Australian Orthodontic Journal*, 27(1), pp.57-62.

Singh, P., Khan, A. and Bharti, M., 2020. Changes in the Sequence of Eruption of Permanent Teeth; Correlation between Chronological and Dental Age and Effects of Body Mass Index of 5–15-year-old Schoolchildren. *International Journal of Clinical Pediatric Dentistry*, 13(4), pp.368-380.

Sun, J., Nam, O., Kim, M., Lee, H. and Choi, S., 2016. Predictive Factors of Ectopic Eruption of the Maxillary First Permanent Molar. *THE JOURNAL OF THE KOREAN ACADEMY OF PEDTATRIC DENTISTRY*, 43(3), pp.284-291.

Sutton, P. and Graze, H., 1985. The Blood-Vessel Thrust Theory of tooth eruption and migration. *Medical Hypotheses*, 18(3), pp.289-295.

Sweet, C., 1939. Ectopic Eruption of Permanent Teeth. *The Journal of the American Dental Association*, 26(4), pp.574-579.

Verdonck, A., Jorissen, E., Carels, C. and Thilio, J., 1993. The interaction between soft tissues and the sagittal development of the dentition and the face. *American Journal of Orthodontics and Dentofacial Orthopedics,* 104(4), pp.342-349.

Wang, X., 2013. Tooth Eruption without Roots. *Journal of Dental Research*, 92(3), pp.212-214.

Wise, G. and King, G., 2008. Mechanisms of Tooth Eruption and Orthodontic Tooth Movement. *Journal of Dental Research*, 87(5), pp.414-434.

Yaseen, S., Naik, S. and Uloopi, K., 2011. Ectopic eruption - A review and case report. *Contemporary Clinical Dentistry*, 2(1), p.3.

Yassin, S., 2016. Prevalence and distribution of selected dental anomalies among saudi children in Abha, Saudi Arabia. *Journal of Clinical and Experimental Dentistry*, 8.

Zou, J., Meng, M., Law, C., Rao, Y. and Zhou, X., 2018. Common dental diseases in children and malocclusion. *International Journal of Oral Science*, 10(1).

9. APPENDICES

APPENDIX I: Ethical Approval

29 September 2020

Ali Akbar
Resident – Pediatric Dentistry
Hamdan Bin Mohammed College of Dental Medicine

RE: MBRU-IRB-2020-037

Dear Dr Rashid,

Thank you for submitting to the IRB application titled "Patterns and severity of ectopic eruption of first permanent molar in 5-12 years old children attending Dubai Dental Hospital in UAE" for exempt review. The Board has reviewed the same and has agreed to approve the application.

The project can now commence. Any change in protocol should be notified to the Board.

For any questions, please contact the Institutional Review Board irb@mbru.ac.ae.

Thank you for your interest in MBRU's IRB.

Yours Sincerely,

Essa Kazim, FRCS
Chairman, MBRU-IRB

APPENDIX 2: Grading of Ectopic Eruption: Hennessy, J., Al-Awadhi, E., Dwyer, L. and Leith, R., 2012. Treatment of ectopic first permanent molar teeth. Dental Update, 39(9), pp.656-661.

Ectopic eruption grade	Severity	Effect on primary molar
Grade 1	**Mild**	Limited resorption to the cementum or with minimum dentine penetration
Grade 2	**Moderate**	Resorption of the dentine without pulp exposure
Grade 3	**Severe**	Resorption of the distal root leading to pulp exposure
Grade 4	**Very Severe**	Resorption that affects the mesial root of the primary second molar

Table 1. Describes the classification of ectopically erupting first permanent molars.

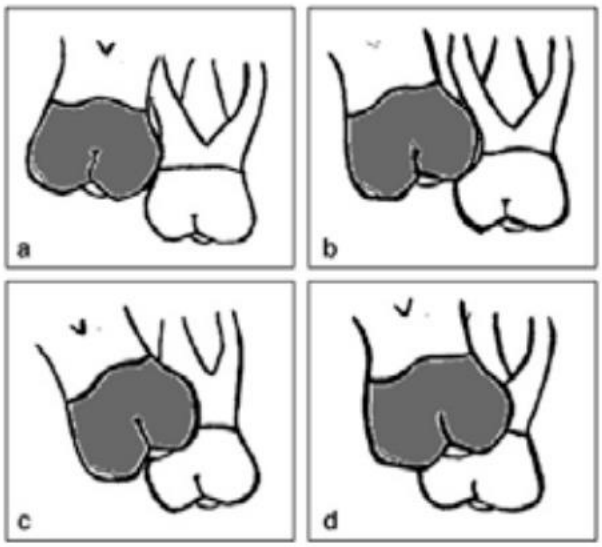


Figure 1. (a–d) The grades of resorption of the second primary molar.