MOLAR-INCISOR MALFORMATION: A NARRATIVE REVIEW

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Palavras-chave: Malformação Molar-Incisivo. Malformação radicular Molar-Incisivo. Malformação Radicular. Desenvolvimento Radicular. Raízes Dentárias. Anormalidades

RESUMO

Introdução: "Malformação molar-incisivo" (MIM) ou "Malformação radicular molar-incisivo" é uma anomalia dental recém-reportada de etiologia desconhecida, possivelmente associada a complicações sistêmicas, que afeta o desenvolvimento de raízes dos primeiros molares permanentes e esmalte dentário de incisivos centrais. **Objetivo**: Realizar uma revisão da literatura sobre "Malformação molar incisivo", também conhecida como "Malformação raiz-molar incisivo", discutindo seus aspectos clínicos, radiográficos/tomográficos, diagnóstico diferencial e possibilidades de tratamento. Fonte dos dados: Busca eletrônica foi realizada na base MEDLINE, em março de 2021, sem limite quanto ao ano de publicação. Os termos pesquisados foram "molar-incisor malformation", "molar-root incisor malformation", "root malformation", "root development", "tooth roots", "abnormalities". **Síntese dos dados**: Quinze artigos, na maioria série de casos, foram incluídos. Em geral, a história médica revelou complicações clínicas durante a gestação e/ou primeiros anos de vida. As características clínicas incluíram defeitos de esmalte dentário na região cervical de incisivos e mobilidade acentuada de molares e incisivos permanentes. Radiograficamente, observou-se a presença de câmaras pulpares parcialmente obliteradas, raízes de molares e incisivos permanentes curtas, finas e incompletas. Microscopicamente, reportou-se a ocorrência de camada de dentina hipercalcificada, em forma de lente, no interior da câmara pulpar, ao nível da junção cemento-esmalte, denominada de "diafragma cervical mineralizado". **Conclusão**: A "Malformação molar-incisivo" é uma anomalia caracterizada por alterações do desenvolvimento radicular, da câmara pulpar e do esmalte em molares e incisivos permanentes. O diagnóstico diferencial inclui Displasia dentinária tipo I e Odontodisplasia regional. Históricos médico e familiar são essenciais para o diagnóstico final, e o tratamento, o qual apesar de não ter protocolo estabelecido requer abordagem multidisciplinar e tratamentos convencionais como exodontia, endodontia, ortodontia e implantes dentários.

Keywords: Molar-incisor malformation. Molar-root Incisor Malformation. Root Malformation. Root Development. Tooth Roots. Abnormalities.

ABSTRACT

Introduction: "Molar-incisor malformation" (MIM) or "Molar root-incisor malformation" is a recently reported dental anomaly of unknown etiology, possibly associated with systemic complications, which affects the development of first permanent molar roots and dental enamel of central incisors. Objective: To conduct a literature review on "Molar-incisor malformation", also known as "Molar root-incisor malformation", discussing its clinical, radiographic/tomographic and microscopic aspects; differential diagnosis and treatment possibilities. **Sources of data**: Electronic search was performed on the MEDLINE database in March 2021, without limit regarding the year of publication. The terms used were "molar-incisor malformation", "molar-root incisor malformation", "root malformation", "root development", "tooth roots", "abnormalities". **Synthesis of data**: Fifteen articles, most of them case series, were included. In general, medical history revealed clinical complications during pregnancy and / or the first years of life. Clinical features included tooth enamel defects in the cervical region of incisors and marked mobility of permanent molars and incisors. Radiographically, partially obliterated pulp chambers, short, thin and incomplete roots of first permanent molars and incisors, were observed. Microscopically, the occurrence of a hypercalcified dentin layer, in the form of a lens, inside the pulp chamber, at the level of the cementum-enamel junction, called "mineralized cervical diaphragm", was reported. **Conclusion**: "Molar-incisor malformation" is an anomaly characterized by changes in root development, pulp chamber and enamel in permanent molars and incisors. The differential diagnosis includes Dentin Dysplasia type I and Regional Odontodysplasia. Medical and family histories are essential for the final diagnosis, and treatment, which despite not having an established protocol, requires a multidisciplinary approach and conventional treatments such as tooth extraction, endodontics, orthodontics, and dental implants.

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INTRODUCTION

Dental development is a complex process that involves strict molecular control regulated by signals that are transmitted between the epithelium and the neural crest derived from the mesenchyme[1]. The discontinuation of this process can lead to abnormal tooth development, due to complex interactions between genetic, epigenetic and environmental factors, which can manifest as changes in number, shape, changes in the mineralized matrix of the tooth.[2,3]

"Molar-incisor malformation" (MIM), also known as "Molar root-incisor malformation" (MRIM), is a newly reported type of dental anomaly with malformation of the roots of first permanent molars[4] and characteristic enamel defect in the central incisors crown. The condition is mainly represented by deviations in the root development of the first permanent molars. The roots are usually very thin and malformed and, many times, nonexistent, although the crown of the affected teeth present clinically typical morphologies. In addition, MIM can affect deciduous second molars.[3,5,6]

This anomaly may cause clinical impairments such as tooth impaction, tooth loss, loss of space, spontaneous pain and poor aesthetic of the incisors.[7] It is assumed that the etiology of a tooth with MIM differs from other hereditary and environmental dental anomalies previously described. Although similar to dentin dysplasia (DD) type I, which, is hereditary and may affect the both dentitions partially or completely, MIM affects first permanent molars. Moreover, the medical history of patients with MIM reveals health problems, including neurological disorders, such as myelomeningocele and meningitis, and systemic conditions, such as kidney disease, premature birth and low birth weight or in the first 2 years of life in most cases.[5,6]

The aim of this study was to conduct a literature review on "Molar-incisor malformation", also known as "Molar root-incisor malformation", discussing its clinical, radiographic/tomographic and microscopic aspects, differential diagnosis and treatment possibilities.

MATERIALS AND METHODS

Data source and eligibility criteria

An electronic search was conducted on the MEDLINE database (via PubMed) in March 2021, without limit regarding the year of publication, using the terms "molar-incisor malformation", "molar-root incisor malformation", "root malformation", "root development", "tooth roots", "abnormalities". Clinical studies that reported clinical, radiographic/tomographic and/or microscopic aspects, differential diagnosis and/or treatment approaches of MIM, were included. Conversely, clinical studies that were not related to MIM or were about other root abnormalities, were excluded. In addition, review studies and conference abstracts were also excluded.

Data extraction

The data regarding the country, type of study; sample size; age of participants; reporting of brain injuries; premature birth; occurrence of infections at prenatal or first year periods; clinical and radiographic oral manifestations; microscopic aspects and treatments, were extracted.

RESULTS

A total of fifteen articles, most of them case series, published in English, in their full version, with relevance to the topic studied were included in this review. Briefly, the reported medical histories revealed clinical complications during pregnancy and / or the first years of life. Clinical features included tooth enamel defects in the cervical region of incisors and marked mobility of permanent molars and incisors. Radiographically, partially obliterated pulp chambers, short, thin and incomplete roots of first permanent molars and incisors. The occurrence of a hypercalcified dentin layer, in the form of a lens, inside the pulp chamber, at the level of the cementum-enamel junction, called "mineralized cervical diaphragm" was reported as a microscopic characteristic.

Synthesis of data

The main characteristics regarding country, sample size, age of participants, medical history (concerning the occurrence of brain injuries, premature birth, infections or other complications), and oral manifestations (clinical, radiographic/tomographic) of MIM reported in the case reports and series included, were described in Table 1. Reported possible etiology, microscopic characteristics, differential diagnosis, and treatments were presented descriptively.

Table 1: *Main characteristics of the included studies.*

Reference and study location	Type of study	Sample size	Age of participants	Medical history				Oral manifestations	
				Brain injuries	Premature birth	Infections	Others	Clinical	Radiographic/ tomographic
Lee *et al.*, 2014[7] South Korea	Case series	2	4 and 13 years old	Yes	Yes	No	No	Impaction, early exfoliation, loss of space, spontaneous pain, periodontal abscess, defective aesthetics, mobility of the first molars and permanent central incisors	Permanent first molars and deciduous second molars with thin and short roots
Witt *et al.*, 2014[8] Switzerland	Case series	2	8 and 10,5 years old	No	Yes	Yes	No	Normal-looking clinical crowns	Radiographic: dysplastic roots in the first four permanent molars.Micro-CT: CMD (cervical-mineralized diaphragm) at the level of cemento-enamel junction was found in the analysis of the extracted molars. Intermingled in the calcified matrix, soft tissue canals networks were observed. The buccal roots of the maxillary molars were narrow or elementary. In the mandibular molars the roots were shorts.

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Reference and study location	Type of study	Sample size	Age of participants	Medical history				Oral manifestations	
				Brain injuries	Premature birth	Infections	Others	Clinical	Radiographic/ tomographic
Lee *et al.*, 2015[9] South Korea	Case report	1	6 years old	Yes	Yes	No	Yes	Normal-looking clinical crowns and severe mobility in the permanent and primary molars affected by MIM	Radiographic: first permanent molars with short and thin roots. Micro-CT: a calcified matrix did not entirely obliterate the canal roots of the upper right permanent first molar. A radiopacity in the lower right permanent molar was found between the enamel and dentin.
McCreedy *et al.*, 2015[10] USA	Case series	2	8 and 9 years old	No	Yes	No	Yes	Cervical constriction and enamel defect on the upper permanent incisor and mobility	First permanent molars with atrophied pulp chambers and short and narrow roots
Wright *et al.*, 2016[11] USA/South Korea	Case series	30	Not reported	No	No	Yes	Yes	Permanent incisors with cervical constriction	First permanent molars with thin and dysplastic roots
Yue an d Kim *et al.*, 2016[12] South Korea	Case report	1	13 years old	No	No	Yes	No	Gingival hidradenitis suppurativa	First permanent molars with thin roots and small atrophied pulp chambers

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Reference and study location	Type of study	Sample size	Age of participants	Medical history				Oral manifestations	
				Brain injuries	Premature birth	Infections	Others	Clinical	Radiographic/ tomographic
Brusevold *et al*., 2017[5] Norway	Case series	6	8 – 12 years old	Yes	Yes	No	Yes	Cervical constriction on the upper central incisor	Radiographic: first permanent molars with hypoplastic roots, limited pulp chambers.Micro-CT: a lower left first permanent molar was observed. Although the dentin and enamel were normal, the pulp chamber only connected with one canal and was partially obliterated. A denser layer of dentin was found and correlated with a cervical enamel constriction.
Choi *et al*., 2017[6] South Korea	Case series	3	6 -9 years old	No	No	Yes	Yes	Gingival abscess, defect in the cervical region of the upper central incisor	Radiographic: First permanent molars with underdeveloped roots, bone resorption

Table 1: *Main characteristics of the included studies.*

Reference and study location	Type of study	Sample size	Age of participants	Medical history				Oral manifestations	
				Brain injuries	Premature birth	Infections	Others	Clinical	Radiographic/ tomographic
Kim *et al*., 2019[16] South Korea	Case series	38	3 – 23 years old	Yes	Yes	Yes	Yes	Wedge-shaped defect in permanent incisors or canines in the cervical portion of the crown and mobility	Affected molars with underdeveloped, short and slender roots. Micro-CT: revealed CMD in the cemento-enamel junction in a lower permanent first molar. Also, primitive roots were observed. However, in a second observed tooth, CMD was at the middle section of the crown of an upper permanent first molar, instead at the level of the cemento-enamel junction. A fissure was observed in the cervical region, on the external face of the crown, at the CMD region. Dysplastic and malformed roots were also described.
Neo *et al*., 2019[14] UK	Case report	1	12 years old	No	No	No	Yes	Normal-looking clinical crowns	Extensive root resorption or under development of the roots was observed, little root structure. Pulpal spaces were thin and crescent-shaped.
Pavlic *et al*., 2019[15] Slovenia	Case report	1	12,5 years old	No	No	No	Yes	Hypoplastic cervical third of the upper permanent incisors	First permanent molars with atrophied pulp chambers and short and narrow roots

Table 1: Main characteristics of the included studies.

Reference and study location	Type of study	Sample size	Age of participants	Medical history				Oral manifestations	
				Brain injuries	Premature birth	Infections	Others	Clinical	Radiographic/ tomographic
Vargo *et al*., 2019[16] USA	Case series	8	3-19 years	Yes	Yes	Yes	Yes	Incisors with wedge-shaped enamel defect in the cervical one-third but also unremarkable crowns, defects on the crown of permanent mandibular canines	Malformed, short maxillary central incisor roots, root malformation of the permanent molars
Vieira *et al*., 2020[17] Brazil	Case report	1	8 years old	No	No	No	Yes	Fluorosis stain and hypoplasia on teeth 11 and 31 and mobility in the upper and lower permanent incisors	First permanent molars with short roots and open apices, incomplete root formation of the incisors
Kim *et al*., 2020[18] South Korea	Case series	2	6 and 7 years old	Yes	Yes	No	No	Mobility of the lower left second primary molar	Radiographic: Unerupted permanent central incisors exhibited a cervical notch of the crown, root malformations and almost rootless of second primary molars and first permanent molars with dysplastic roots.Micro-CT: analysis of an extracted lower first permanent molar revealed CMD at the cemento-enamel junction, also a narrow cervical region with small and thin roots.
Park *et al*., 2020[19] South Korea	Case series	2	10 and 11 years old	Yes	Yes	Yes	Yes	Abscess, periapical abscess and normal-looking clinical crown	Abnormal furcation position, shorten middle of tooth, constricted pulp cavities, elongated and shorted roots

Etiology

The etiology of MIM remains undetermined, however, some studies indicated that MIM is caused by environmental factors and is related to medical history, such as the use of drugs and diseases related to the central nervous system.[6,7,9] Most patients had health problems such as myelomeningocele in the first two years of life,[6,11] premature delivery,[6-9,13,16,18,19] meningitis,[7,11,13,16] convulsion,[5,7,13] perinatal asphyxia,[9,10,13,16,19] cerebral hemorrhage,[5,9,13,18] Staphylococcus infection,[8,12] autoimmune lymphoproliferative[15], and abortion attempts during pregnancy.[17]

Microscopic characteristics

Analysis of histological sections revealed narrow pulp chamber, in which the dentin layer on the floor had a normal appearance, while cervical to the this tissue an altered dentin layer was observed, with irregular and globular aspects. The layer of hypercalcified dentin seemed to prevent the connection of the pulp chamber with the root canals.[5] Similarly, amorphous dentin and altered pulp chamber in the middle portion of the crown, despite the normal dentin and pulp in the upper section, were observed.[7] Although root fractures were not observed, abnormal dentin, cementum and pulp tissue were observed, in addition to inflammatory cells in a region of abnormal root dentin fissure.[7] In another study, normal and amorphous dentin were observed on the upper section of the pulp floor, while osteodentin-like and hyperactive cells similar to pulp were disclosed on the middle and on the lower sections of the pulp floor, as well as the presence of an amorphous tissue similar to cementum-cells.[9] A study reported narrow pulp chambers between the roof and the floor, which were considered as dysplastic areas with irregular contours.[11] The pulp chambers presented with several pulp inclusions that resembled disorganized dentin. In the upper portion of the pulp chamber, normal dentin that extended to the dentin-enamel junction was observed. The roots presented abnormal morphology.[11] In addition, some studies reported the occurrence of a densely calcified plate, "cervical-mineralized diaphragm (CMD) that was located cervical to the pulp chamber and approached the edge of the enamel.[8,15] According to Witt (2014), the CMD was formed by densely calcified globules, having a diameter of approximately 2-3 mm, alternating with a moderately mineralized matrix, which was passed through a dense network of soft tissue channels.[8] Close to the CMD, an amorphous tissue like sclerotic dentin was disclosed, as well as cells like chondrocytes in the portion where the dentin appeared thinner. In the cervical section, instead of the pulp and furcation, cellular cement and a small amount of periodontal ligament were also observed. In the root canals, normal pulp tissue was found, although blocked by mineralized structures that looked like pulp stones[15]. Moreover, it was observed the occurrence of pulp cavity floor composed of dentin coated with a pre-dentin layer and cells equivalent to odontoblasts, while partially developed root segments were covered by acellular cementum.[8] Regarding the dentinal tubules, it was observed that those changed their course in the coronal direction and ran almost horizontally along the edge of the CMD towards the pulp cavity.[8]

Differential diagnosis

The final diagnosis of MIM can only be confirmed by excluding other conditions with similar clinical and radiographic characteristics: Dentin Dysplasia type I and Regional Odontodysplasia. Dentin Dysplasia type I (DD type I) is an anomaly in which the enamel and coronary dentin are clinically normal and well-developed, but the root dentin is disorganized leading to shortening of the root. Unlike MIM, this condition is hereditary and is also called "rootless teeth".[20,21] Dentinal disorganization can happen at different stages of tooth development, which can vary from one patient to another and from tooth to tooth in the same patient. The most affected were deciduous teeth and, in permanent teeth, it depends on the proportion of dentin between organized and disorganized dentin.[20] Dentin Dysplasia type I can affect the entire dentition, on the other hand, MIM is a disease localized to specific teeth.[18] In addition, periapical radiolucencies are frequently observed in non-carious teeth with DD type I even when they exhibit pulp chambers and root canals almost completely obliterated.[14] Regional odontodysplasia is a non-hereditary condition in which the development of enamel and dentin were affected, therefore, is also referred to as "ghost teeth". Most cases were idiopathic, but others seem to be related to syndromes, growth abnormalities, neural disorders and vascular malformations.[20] Although MIM teeth does not present any of these characteristics, radiographically, in cases of regional odontodysplasia is possible to observe the thin layers of enamel and dentin, large pulp chambers and various adjacent teeth being affected.[18] However, this condition can resemble MIM when it presents smaller roots, open apexes and show pulp calcifications.[20]

Treatment

Patients with MIM must be constantly monitored by the dental team for the correct diagnosis and elaboration of a comprehensive conservative treatment plan, considering the patient's signs and symptoms in order to avoid pain and early tooth loss.[5,7] Teeth with MIM should be extracted only when necessary or to avoid more painful treatments and

further complications.[5] Endodontic treatment can also be considered in cases of apical abscesses in teeth affected by MIM, however the treatment has a high degree of difficulty, as there is the "cervical mineralized diaphragm" (CMD), several accessory channels and absence of periodontal support.[3,13,19] The participation of an orthodontist in MIM cases is extremely important, since orthodontic treatments and even implant installation can be considered after tooth loss and, even so that the professional advises the best time to perform the extraction of the affected tooth.[7,13]

DISCUSSION

The "Molar-incisor malformation" (MIM) is a dental anomaly recently described in the literature, with few published articles, most of which were case series[5-8,10,11,13,16,18,19] and case reports,[9,12,14,15,17] with small sample sizes. MIM has been observed and reported in several countries such as Brazil, South Korea, Slovenia, United Kingdom, United States, Norway, Switzerland, although the prevalence of the anomaly has not yet been determined.

MIM is characterized by a failure in the development of the root of first permanent molars, despite the crowns of these teeth present normal aspect, contour and superficial resistance. Major complaints such as spontaneous pain; mobility; swelling; edema; inflammation; pulp necrosis; periapical abscess sinus tract in the gums; loss of space; unusual root development; dental caries without a history of pain; difficulty in endodontic treatment due to uncontrolled bleeding and calcified root canals; and –possible dentinal alterations– have been reported.[6-11,13,19,15,17] Otherwise, some patients had no clinical signs and symptoms and discovered the anomaly in routine consultations and through panoramic radiographs.[10,13] The roots were usually underdeveloped, thin and malformed, and may even be absent. The pulp chamber is abnormal, narrow in the coronary portion. Commonly, all first permanent molars are affected, mainly the lower ones.[5,11,15] The permanent incisors, when affected, exhibit a constriction in the crown in the cervical region, in the shape of a wedge and morphological changes in the pulp chamber and in the root. In some cases, the roots of the second deciduous molars were also affected, presenting deformities similar to those of permanent first molars.[5,11,12,17,18]

The panoramic radiographs of patients with MIM showed first upper and lower permanent molars roots with abnormal morphology.[5-7,10] These roots were characterized as underdeveloped, short, narrow, and divergent. In some cases, pulp obliteration, open apexes, visible alveolar bone loss in the furcation region and even absent roots were also observed. Due to a marked reduction in height, the coronary pulp chambers were partially obliterated, hypercalcified and with evident constriction in the form of narrow slits.[5-8] In the upper central incisors, constrictions were noted in the cervical third of the crown. The roots of these teeth were described as having a normal aspect, in most cases, however, they were also reported with incomplete root formation.[5,17] The roots of the permanent central incisors, when affected, showed open and wide root apexes, and altered ratio between the sizes of the crown and the root.[17]

Bruseovld *et al*. (2017)[5], Choi *et al*. (2017)[6], and Kim *et al*. (2020)[18] observed first permanent lower molars extracted through Microcomputed tomography (Micro-CT) and noticed the pulp partially obliterated, and the pulp chamber hardly connecting with root canals.[5] A layer of hypercalcified dentin, that was denser, was found in the cervical third for the pulp chamber, close to a layer of dentin with normal density. Interestingly, this hypercalcified denser layer represented an association with constriction of the cervical enamel.[5] Likewise, the analysis by Choi *et al*. (2017)[6] and Kim *et al*. (2020)[18], revealed a mineralized plaque in the cervical region inside the pulp chamber, extending to the cemento-enamel junction. The root canals did not seem to have differentiated correctly into fully formed canals and, in addition, the non-development of the roots was also observed. The mineralized plaque was also observed at the average crown height, inside the pulp chamber. Dysplastic roots were intertwined, generating irregular channel morphology. In addition, the presence of calcified materials was found in the pulp cavity. The external shape of the crown was also affected, with a crack in the enamel in the region of the plaque and irregular protrusions in the cervical.[6] Witt *et al*. (2014)[8] and Luder *et al*. (2015)[4], also observed through Micro-CT an ectopic mineralized plate, in the form of a lens at the level of the cemento-enamel junction, which was called "cervical mineralized diaphragm" (CMD). Therefore, this condition came to be called "root malformation associated with a cervical mineralized diaphragm" (RM-CMD). The mineralized plate involved densely calcified globules, sometimes agglutinated, linked to a moderately mineralized collagen matrix, as well as a network of soft tissue channels including large blood vessels and connective tissue similar to the periodontal ligament. According to Witt *et al*. (2014)[8], the plates extended until close to the enamel margin, however, in other areas, they allowed a certain space for fixing the roots.

The etiology remains uncertain.[6,17] However, genetic and epigenetic factors cannot be totally discarded, studies indicated that this condition is caused by different environmental factors that would be associated with the abnormal formation of the tooth root.[7,8,15] Past medical history, including drugs,[7] infection,[11,12] diseases related to the central nervous system,[5-7,11] premature birth,[3,8,11,20] asthma,[18,10,14] especially in the first two years of life, were suggested as possible causes.[8,9,13]

Meningitis is an injury to the central nervous system, characterized as inflammation of the subarachnoid space and can be caused by viral or bacterial infection. If the origin of meningitis is bacterial, treatment with antibiotics should be started immediately.[7] In addition, according to Kim *et al*. (2019), in South Korea, the use of antibiotics to treat premature babies is standard procedure. On the other hand, despite the patient enjoying a good general health during the first three years of life, there was a report of problematic pregnancy, which may suggest the association of environmental factors root malformation of molars and coronary cervical constrictions in the incisors.[17]

The age range of patients diagnosed with MIM was between 3 and 23 years.[5-12,14-19] Even reporting 30 cases of MIM, Wright *et al*. (2016), did not mention the average age of patients who participated in the study. Adequate diagnosis must be made based on clinical and radiographic examination, relating the patient's medical history, mainly during the neonatal period.[13] The difficulties in diagnosing MIM cases were due to the few studies published in the literature to date and, mainly, the unknown etiology of this condition.

Due to the few studies and types of studies, there is still no evidence regarding the best treatment for this anomaly. Meanwhile, patients with MIM are strong candidates for strict monitoring by the dental team, in order to promote a favorable prognosis, especially for children and adolescents.[5,13] Conventional treatments include apicectomy and endodontic treatment.[9] On the other hand, many cases benefit from the extraction of the tooth affected by MIM, followed by orthodontic treatment, allowing healthy second permanent molars to occupy the space.[5,10,13] Dental implants, as long as there is preservation of space and alveolar bone, can be also be considered after tooth loss.[5,10,13]

Endodontic treatment is a challenge as a result of the "cervical mineralized diaphragm" (CMD) located in the pulp chamber, the various accessory channels and the absence of periodontal support.[13,19] Despite this, less than half of the patients lost one or more teeth affected by MIM during the follow-up period.[13] Corroborating the study by Yue *et al*. (2016)[12], in which endodontic treatment was performed on the first left permanent molar diagnosed with MIM, that after six months of follow up, was asymptomatic and with normal healing of the periapical tissues and with normal depth at probing, Park *et al*. (2020) conducted endodontic treatments in two patients and both cases were filled with continuous technique with Endoseal MTA (Maruchi, Wonju, Korea). In addition, the two cases had an exact perforation point and for the correction, Endocem MTA (Marucho, Wonju, Korea) was used. The execution of endodontic treatment on teeth with MIM and its prognosis depends directly on the accessibility of the root canals, since these are often filled with pulp stones.[19] On the other hand, interceptive orthodontic treatment during the permanent dentition was successfully conducted on the patient with MIM, that allowed the interception of deleterious habits and improved overbite and overjet.[17] Kim *et al*. (2020)[18], in one of the cases, not only used a lingual arch to prevent premature loss of the lower second primary molar, but also to maintain and stabilize the first permanent molar until the second permanent molar was capable to restore the place of the affected first permanent molar.

Thus, we observed that there are still very few reports and research in the literature on the "Molar-Incisor Malformation", which impairs the correct diagnosis and treatment, as well as a good prognosis in these cases. Therefore, further studies are necessary for this condition to be, in fact, fully understood.

CONCLUSION

The Molar-incisor malformation (MIM) is an unusual and newly discovered dental anomaly characterized by changes in root development, pulp chamber and enamel in permanent molars and incisors. The differential diagnosis includes Dentin Dysplasia type I and Regional Odontodysplasia. Even with unknown etiology, the diagnosis requires additional information about the patient's medical history in the first two years of life and clinical and radiographic examinations. Treatment is challenging due to the lack of a protocol to date. For this reason, research and studies on the subject are extremely important to contribute to knowledge regarding its etiology and therapeutic possibilities such as tooth extraction, endodontics, orthodontics and implant installation. In addition, interdisciplinary treatment is essential for the correct diagnosis and preparation of a treatment plan to preserve the affected tooth in the mouth for as long as possible.

REFERENCES

1. Huang X-F, Chai Y. Molecular regulatory mechanism of tooth root development. Int J Oral Sci. 2012 Dec;4(4):177–81.
2. Bei M. Molecular genetics of tooth development. Current Opinion in Genetics & Development. 2009 Oct;19(5):504–10.
3. Cobourne MT, Sharpe PT. Diseases of the tooth: the genetic and molecular basis of inherited anomalies affecting the dentition: Diseases of the tooth. WIREs Dev Biol. 2013 Mar;2(2):183–212.
4. Luder HU. Malformations of the tooth root in humans. Front Physiol [Internet]. 2015 Oct 27 [cited 2020 Nov 3];6. Available from: http://journal.frontiersin.org/Article/10.3389/fphys.2015.00307/abstract

5. Brusevold IJ, Bie TMG, Baumgartner CS, Das R, Espelid I. Molar incisor malformation in six cases: description and diagnostic protocol. Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology. 2017 Jul;124(1):52–61.

6.Choi S, Lee J, Song J. Molar-Incisor Malformation: Three Cases of a Newly Identified Dental Anomaly. THE JOURNAL OF THE KOREAN ACADEMY OF PEDTATRIC DENTISTRY. 2017 Aug 31;44(3):370–7.

7.Lee H-S, Kim S-H, Kim S-O, Lee J-H, Choi H-J, Jung H-S, et al. A new type of dental anomaly: molar-incisor malformation (MIM). Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology. 2014 Jul;118(1):101-109.e3.

8.Witt CVA, Hirt T, Rutz G, Luder HU. Root malformation associated with a cervical mineralized diaphragm – a distinct form of tooth abnormality? Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology. 2014 Apr;117(4):e311–9.

9. Lee H-S, Kim S-H, Kim S-O, Choi B-J, Cho S-W, Park W, et al. Microscopic analysis of molar–incisor malformation. Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology. 2015 May;119(5):544–52.

10. McCreedy C,Robbins H, Newell A, Mallya SM. Molar-incisor Malformation: Two Cases of a Newly Described Dental Anomaly. J Dent Child 2016;83(1):33-7.

11. Wright JT, Curran A, Kim K-J, Yang Y-M, Nam S-H, Shin TJ, et al. Molar root-incisor malformation: considerations of diverse developmental and etiologic factors. Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology. 2016 Feb;121(2):164–72.

12.Yue W, Kim E. Nonsurgical Endodontic Management of a Molar-Incisor Malformation-affected Mandibular First Molar: A Case Report. Journal of Endodontics. 2016 Apr;42(4):664–8.

13.Kim J-E, Hong J-K, Yi W-J, Heo M-S, Lee S-S, Choi S-C, et al. Clinico-radiologic features of molar-incisor malformation in a case series of 38 patients: A retrospective observational study. Medicine. 2019 Oct;98(40):e17356.

14. Neo H-LL, Watt EN, Acharya P. Molar-incisor malformation: A case report and clinical considerations. J Orthod. 2019 Dec;46(4):343–8.

15. Pavliè A, Vrecl M, Jan J, Bizjak M, Nemec A. Case report of a molar-root incisor malformation in a patient with an autoimmune lymphoproliferative syndrome. BMC Oral Health. 2019 Dec;19(1):49.

16.Vargo RJ, Reddy R, Da Costa WB, Mugayar LRF, Islam MN, Potluri A. Molarincisor malformation: Eight new cases and a review of the literature. Int J Paediatr Dent. 2020 Mar;30(2):216–24.

17.Vieira FGF, Pintor AVB, Abrahão AC, Ruellas ACO, Visconti MA, Primo LG. Differential diagnosis, three-dimensional imaging aspects and interceptive orthodontic management of molar–incisor malformation. Int J Case Rep Images. 2020;11:1.

18.Kim MJ, Song J-S, Kim Y-J, Kim J-W, Jang K-T, Hyun H-K. Clinical Considerations for Dental Management of Children with Molar-Root Incisor Malformations. Journal of Clinical Pediatric Dentistry. 2020 Jan 1;44(1):55–9.

19.Park S, Byun S, Kim J, Yang B, Oh S. Treatment of Molar Incisor Malformation and the short term follow-up: Case reports. European Journal of Paediatric Dentistry. 2020;21(3):238–42.

20.Neville BW, editor. Oral and maxillofacial pathology. 3. ed. St. Louis, Mo: Saunders/Elsevier; 2009. 968 p.

21. Pintor A, Alexandria A, Marques A, Abrahao A, Guedes F, Primo L. Histological and Ultrastructure Analysis of Dentin Dysplasia Type I in Primary Teeth: A Case Report. Ultrastructural Pathology. 2015 Jul 4;39(4):281–5.