Selective excavation and ozone therapy: new frontier of mini-invasive caries treatment in MIH paediatric patients. A case report

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Abstract

The term hypomineralisation of molars and incisors (MIH), introduced in 2001 by Weerheijm et al., describes a clinical state of hypomineralisation of permanent molars with frequent involvement of the incisors. MIH is considered a global dental problem with a prevalence ranging from 2.4% to 40.2% in the entire world paediatric population. The continuous increase in the prevalence of enamel anomalies, including MIH, indicates the need to define new intervention protocols based on the technological advances that are revolutionising paediatric dentistry. The use of ozone associated with the selective and minimally invasive excavation of the dental tissue combines the antibacterial properties of the gas with an ultra-conservative approach aimed at the maximum conservation of the dental tissue. The operative protocol described can be an important tool in the prevention and treatment of MIH. The aim of this work is to illustrate an operative clinical protocol based on the combined use of selective excavation and ozone for the treatment of carious lesions in paediatric patients with MIH.

KEYWORDS Paediatric dentistry, MIH, hypomineralisation, caries, caries prevention, ozone therapy.

Introduction

MIH - Molar Incisor Hypomineralisation

The term hypomineralisation of molars and incisors (MIH), was first introduced in 2001 by Weerheijm et al. and defines a typical clinical picture, with pathogenesis still not clear, characterised by the deficit in the mineralisation process of the tooth, due to the lack of calcium and phosphate fixation in the matrix formed by the ameloblasts. The causes are associated with systemic pathologies that occur during the embryonic phase and the first years of the patient's life. MIH, together with other pathological pictures characterised by enamel anomalies, represents one of the most serious clinical pictures in paediatric dentistry according to Giuca et al. [2020], presenting a prevalence ranging from 2.4% to 40.2% in the entire paediatric population worldwide. Clinically, the enamel affected by MIH appears porous, with a chalky appearance, characterised by white, yellow, or brown spots. The accentuated porosity of the enameled tissue determines, over time, a greater fragility of the affected teeth, which, as a result of the occlusal forces during chewing, can quickly undergo fracture. The sudden loss of enamel can simulate enamel hypoplasia, but the latter is characterised by linear margins in contact with healthy enamel, while in MIH the edges of the defect are irregular [Caruso et al., 2014] . The hypomineralisation of enamel in MIH can occur in a mild, moderate, or severe form. The mild form is characterised by an alteration in the color of the enamel, without fractures or hypersensitivity. There are no caries lesions and the incisors, if involved, show minimal lesions.

Moderate MIH presents with a loss of dental substance and opacities on the occlusal/incisal third. There are fractures of one or more surfaces and post-eruptive enamel breakdown can occur. In the case of severe MIH, there may be post-eruptive fractures and pronounced hypersensitivity associated with severe cervical lesions with pulpal involvement [Pasini et al., 2018]. From the anatomical and functional point of view, the structural damage of the tooth reduces its mechanical properties, such as hardness, mineral density, and elasticity: this is reflected in the reduced capacity of resistance to occlusal stress and fracture, in association with reduced resistance to thermal, chemical and mechanical stimuli [Caruso et al., 2016; Lygidakis et al. 2008; Dacosta Silva et al., 2011; Wilmott et al., 2008; Lygidakis, 2010]. The clinical management of molars affected by MIH is conditioned by two factors that are not always directly correlated with each other: hypersensitivity to thermal stimuli and the pulp involvement by carious or non-carious processes (rapid demineralisation of exposed dentin or rupture). In all cases, the first goal is always to maintain pulp vitality, as the long-term prognosis of these teeth is strongly influenced by root maturation. In this scenario, the use of ozone, associated with the selective excavation of the affected dental tissue represents an effective solution in the treatment of a carious lesion in a patient with MIH. In mild forms, the clinical therapeutic approach favours remineralisation through the application of topical products. In the medium and severe forms, ozone therapy can be decisive as a preventive and primary therapeutic aid for early cavitated lesions [Caruso et al., 2016; Lygidakis et al. 2008; Dacosta Silva et al., 2011; Wilmott et al., 2008; Lygidakis, 2010]. In the severe form of MIH, when the structural integrity of the first molar is greatly compromised, the extraction of this tooth represents the only therapeutic alternative. Treatment of the severe form of MIH requires close cooperation between the paediatric dentist and orthodontist to determine the optimal time to extract these molars. Several factors such as the child's age, dental crowding, malocclusion, overbite, agenesis, presence of third molars, and the state of adjacent teeth must be considered. The ideal age should be indicated radiographically from the onset of furcation calcification of the mandibular second molar. The orthodontic treatment will include mesialisation of the second and third molars to ensure proper occlusion [Lione et al., 2012; Pavoni et al., 2017; Baldini et al., 2018; Giuca et al., 2015; Giuca et al., 2016].

Selective excavation

Selective Carious Tissue Removal (SCTR) is a minimally invasive procedure for the management of superficial to deep carious lesions in primary and young permanent teeth. The main objective is to prevent exposure of the dental pulp during conventional procedures aimed at the removal of dental tissue affected by caries, subsequently restoring the structural integrity of the teeth without signs or symptoms of irreversible pulp pathology [Kher and Rao, 2020].

The concept underlying the selective removal of carious tooth tissue is that the microorganisms in the residual carious tissue are deprived of micronutrients when the carious lesion is hermetically sealed. The microorganisms thus lose power, slowing down the carious process. The pulp-dentinal complex deposits the reaction dentin on the pulp.

During the procedure, a balance must be struck between the two goals of carious tissue removal:

• Removal of adequate carious tissue to obtain sufficient depth for placement of a stable restoration.

• Prevention of pulp exposure when removing carious tissue.

Ozonotherapy

Ozone was first identified by Christian Friedrich Schönbein in 1840 and has been tested in the medical and dental fields for over 100 years; suffice it to say that it was used, thanks to its antibacterial properties, as a means to disinfect operating theaters in 1856. In the 1930s, Dr. Edward Fisch used ozone therapy to disinfect and treat wounds in his dental offices with great success [Srikanth et al., 2013; Mehlman and Borek, 1987]. The mechanism is interesting and parallels what doctors see with the management of biofilm infections in other parts of the body. Today, ozone therapy is successfully employed in the management of multiple pathological and non-oral clinical pictures such as wound healing, dental caries, oral lichen planus, oral plaque and biofilm, halitosis, gingivitis and periodontal disease, osteonecrosis of the jaws, post-surgical pain, dentinal hypersensitivity [Suh et al., 2019]. In the medical-dental field, ozone can be administered through various formulations, such as gas, water, and oil. Gaseous ozone is applied to the teeth by means of devices that generate ozone gas through an open or a sealed suction system. The aqueous ozone formulation is used as a mouthwash and has antibacterial, antiviral and antifungal properties for gingival and periodontal problems. In the case of dental caries, the use of ozone plays an important role both as a preventive strategy and as a means to decontaminate dentin exposed to bacterial agents. Studies in the literature show that ozone has a sterilising effect, killing cariogenic bacteria and subsequently leading to the arrest of the carious lesion. Castillo et al. [2008] evaluated the antimicrobial effect of ozone on S. mutans. The results showed that applying ozone for 10–20 seconds produced a significant reduction in the number of bacteria. Kim et al. [1999] hypothesise that the reduction in the total number of viable microorganisms within the exposed dentin may be mediated by the oxidising effect of ozone, which kills microorganisms through a mechanism that involves breaking down bacterial cell membranes. Ozone not only kills all harmful bacteria, fungi, viruses, and protozoa but also removes their degradation products which, in the case of carious pathology, due to their acidic nature contribute to the progressive demineralisation of the hard tissues of the tooth [Domb et al., 2014; Nota et al., 2019; Bayson and Beighton, 2007]. Given the ease of use and the absolute convenience of the method, the use of ozone has often focused on the decontamination of carious dentin, especially in the deciduous teeth of very young or uncooperative patients, followed by the application of various products to the to obtain the remineralisation of the surfaces [Bayson and Beighton, 2007].

Materials and Methods

The operating protocol of this case report describes the minimally invasive and ultraconservative approach in the preparation of the carious cavity associated with the use of ozone inside the carious cavity, which leads to decontamination of the residual dentinal tissue (Figs. 1 and 2).

FIG. 1
OPG of a patient in mixed dentition affected by penetrating caries affecting tooth 3.6.

FIG. 2
Tooth 3.6: Class II penetrating and destructive caries affecting the enamel and dentin layer, with indirect involvement of the pulp tissue.

The removal of the dental tissue affected by caries is carried out selectively under a rubber dam, resulting in the preservation of a greater quantity of dental tissue. The residual dental tissue will be decontaminated by the action of ozone (healOzone™ X4, HealOzone Technology, Vernate, Milan, Italy). The restoration of the structural integrity of the tooth will be carried out using a zinc oxide-eugenol cement (Zonalin, Associated Dental Products Ltd Kemdent Works, Purton, Swindon, Wiltshire, United Kingdom). After a follow-up at 6 and 12 months to assess the clinical response of the tooth to chemical, thermal and mechanical stimuli, the treatment will be finalised with the final composite. Approval of the Ethics Committee was not needed because the procedure was considered safe and not invasive and was planned according to the World Medical Organization Declaration of Helsinki.

Operational protocol

- Local anaesthesia, OPTOCaIN® (Molteni Dental, Italy) (20 mg/m2 with adrenaline 1: 80,000) was administered at the bottom of the fornix near the carious tooth [Botticelli et al., 2021].
- Isolation of the working area with a rubber dam (Hygenic® Dental Dam, Coltène/Whaledent GmbH + Co. KG Raiffeisenstraße 30 89129 Langenau, Germany). In Class II cavities with the involvement of the mesial and distal surfaces, the photopolymerisable liquid dam (OpalDam™, Ultradent, 505 West Ultradent Drive South Jordan, UT, USA) was used to obtain adequate isolation (Fig 3).
- Opening of the cavity in the enamel using diamond burs

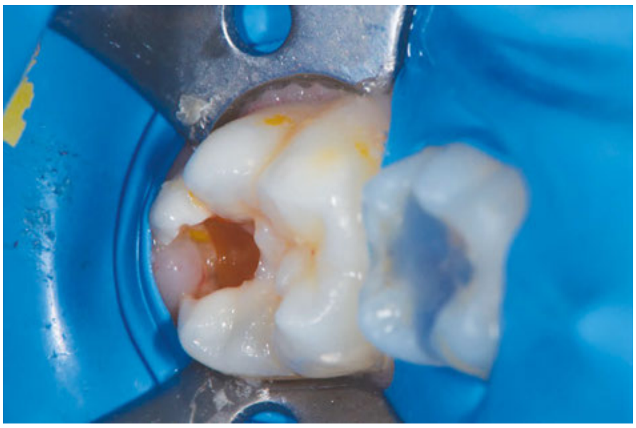


FIG. 3 Tooth 3.6: removal of the carious tissue under the dam by selective excavation.

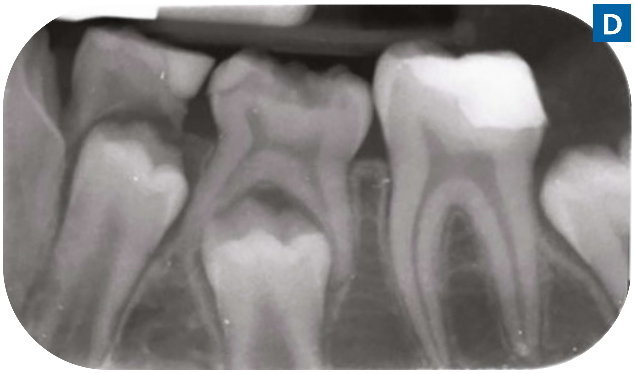
FIG. 4 HealOzone™ X4

FIG. 5 Tooth 3.6: reconstruction using zinc oxide-eugenol cement (Zonalin) after double application of ozone (HealOzone ™ X4) on the dental tissue affected by the carious process.

FIG. 6 Temporary restoration of tooth 3.6 using Zonalin.

and subsequent cleaning and definition of the preparation margin (Fig. 3).
- Removal of the upper layer of carious dentin using a contra-angle micromotor round burs at very low speed, avoiding exposure of the pulp (Fig. 3).
- Double ozone application on the infected dentin for 60 s per administration, with a single-patient silicone cup (HealOzone™ X4) (Fig. 4).
- The disposable cup must be positioned correctly on the tooth because HealOzone is unable to deliver gas without a complete vacuum inside the cup, which must be obtained by properly sealing the cup itself.

FIG. 7
(A, B, C, D) Clinical history of tooth 3.6
(A: time 0; B: selective excavation with the application of zinc oxide-eugenol cement; C: 6-month follow-up with Zonalin; D: composite restoration at 12 months).



- Temporary restoration of the tooth using zinc oxide-eugenol cement (Zonalin-Kemdent)(Figs. 5 and 6).
- Follow-up at 6 and 12 months with a clinical and radiographic evaluation of the tooth for chemical, thermal and mechanical occlusion stress (Fig. 6)
- 2-step adhesive technique (etching, Clearfil™ Universal Bond Quick, Kuraray Europe GmbH, Philipp Reis Str. 4, 65795, Hattersheim / Germany).
- Restoration of the tooth using composite resins (Clearfil Majesty™, Kuraray Noritake), polishing and occlusion control.

Case History

Fig 7. (a, b, c, d) Clinical history of element 3.6
(a: time 0; b: selective excavation with the application of ozone and cement to zinc oxide and eugenol; c: 6-month follow-up with Zonalin; d: composite restoration at 12 months).

Discussion and Conclusion

The continuing increase in the prevalence of enamel abnormalities, including MIH and ECC (Early Childhood Caries) [Severino et al., 2021; Bagattoni et al., 2022; Bagattoni et al., 2021], account for two of the most significant problems in paediatric dentistry today according to Giuca et al. [2020]. Consequently, the need arises to define new, minimally invasive clinical protocols capable of preserving the structural integrity of the tooth and above all its pulp vitality. The use of ozone represents one of the new technological safeguards that is revolutionizing paediatric dentistry. The operative protocol outlined above, according to Berretta et al. [2020], shows a high success rate when the dental pulp is not frankly affected and exposed, with rates comparable to those of pulpotomy, considerably safeguarding healthy dental tissue and reducing treatment times. This protocol is recommended if there is no obvious pre-operative exposure of the pulp tissue; in this case, a pulpotomy with bioceramics is preferable. The main advantages shown by this protocol concern the treatment times, which are much shorter, and the less invasiveness of the clinical compared to a pulpotomy. Less invasiveness is determined by the selective and nontotalitarian removal of dentin exposed to the carious process and less destruction of dental hard tissue in the initial stages of access to the region undermined by the carious process: all this is possible thanks to the antibacterial and decontaminating action of ozone applied in the lumen of the carious lesion. The lower invasiveness is due to the selective partial removal of the exposed dentin and higher preservation of the hard dental tissue to obtain access to the area undermined by caries. This is possible thanks to the antibacterial and decontaminating actions of ozone applied to the cavity.

Follow-up at 12 months shows how the selective excavation protocol associated with the use of ozone leads to a success rate comparable to pulpotomy. The proposed protocol about what has been said regarding the speed and simplicity of execution, has proved effective and efficient in the treatment of deep carious lesions in paediatric patients, both on deciduous and permanent teeth. An important clinical consideration should be made on the state of maturation of the roots of the first permanent molars affected by MIH. The proposed protocol allows normal root development while keeping the pulp chamber intact. Further studies with longer follow-up are needed to evaluate the success of this treatment.

Author Contributions

The investigation, G.B., M.M.; Resources, G.F. and R.G.; Data curation, C.S., D.M.E., D.G.; Writing - original draft preparation, G.B., M.M.; Writing - review and editing, M.M, B.G., R.G. All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement

Informed consent was obtained from the subject involved in the study.

Data Availability Statement

Data will be available upon reasonable request to the corresponding author.

Conflicts of Interest

The authors declare no conflict of interest.

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