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Current Minimally Invasive Treatment Approaches in Molar-Incisor Hypomineralization

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ABSTRACT

Molar-incisor hypomineralization (MIH) is a qualitative defect of enamel development, which mainly affects one or more permanent first molars and often the permanent incisors. Affected teeth may demonstrate well-demarcated white-cream or yellow-brown opacities, post-eruptive enamel breakdown, hypersensitivity, increased susceptibility to dental caries and esthetic concerns. The clinical management of the condition is challenging due to the lower mineral content and reduced mechanical strength of hypomineralized enamel compared with sound enamel [1–4]. The current management strategies for MIH aim to preserve as much sound tooth structure as possible, control hypersensitivity and delay extensive restorative procedures [1,2]. Contemporary minimally invasive treatment options are topical fluoride applications, casein phosphopeptide–amorphous calcium phosphate (CPP-ACP), hydroxyapatite-containing products, fissure sealants, resin infiltration, microabrasion, silver diamine fluoride (SDF), Silver Modified Atraumatic Restorative Treatment (SMART) and conservative restorative procedures [12,17,19]. In this review, current approaches for minimally invasive management of MIH are discussed including indications, advantages and limitations in the light of the available literature.

KEYWORDS: Molar-incisor hypomineralisation, MIH, minimally invasive therapy, remineralization, hyper sensitivity, resin infiltration, SDF.

1. INTRODUCTION

Molar-incisor hypomineralization is a developmental enamel defect of systemic origin in which one or more permanent first molars are affected and permanent incisors are often involved as well [1]. In MIH the enamel thickness is normal at the beginning but the quality of the enamel is decreased due to a disturbance in the mineralization process. Thus, MIH is different from enamel hypoplasia, which is characterized by a quantitative reduction of enamel [3,4].

Clinical presentation depends on the severity of the condition. Mild cases are characterized by well-demarcated white or cream-colored opacities, while more severe cases may show yellow-brown opacities, post-eruptive enamel breakdown, dentin exposure, hypersensitivity and rapid caries development [1,2]. Yellow-brown lesions are generally reported to be more porous and mechanically weaker and thus may be more susceptible to post-eruptive breakdown [3,4].

MIH is a significant clinical problem especially when the permanent first molars are affected. As these teeth erupt in the oral cavity at an early age, the hypomineralized enamel must remain functional for many years. Extensive restorative procedures initiated early in life may result in repeated replacement of restorations and further loss of dental hard tissue over time. Thus, the modern approach to managing MIH comprises not only the restoration of the existing defect but also the early diagnosis and use of preventive, minimally invasive interventions [1,2,12].

2. STRUCTURAL CHARACTERISTICS OF MIH-AFFECTED ENAMEL

The MIH-affected enamel is more porous than normal enamel due to reduced mineralization and increased organic content. Systematic reviews have shown that MIH-affected enamel has lower microhardness and elastic modulus than sound enamel [3,4]. These structural differences have important clinical implications. Hypomineralized enamel is less resistant to masticatory forces and may lose surface integrity after tooth eruption. This phenomenon is called post-eruptive enamel breakdown and it can lead to dentin exposure, increased plaque retention and the development of dental caries [4,6].

In addition, the enamel affected by MIH has higher protein content which may compromise the bond of adhesive dental materials. Thus the clinical performance of fissure sealants and composite restorations may be less predictable than on sound enamel [2–4]. Thus, treatment planning for MIH should consider not only the clinical appearance of the lesion, but also the structural characteristics of the enamel.

3. BASIC PRINCIPLES OF MINIMALLY INVASIVE TREATMENT

The main objective with a minimally invasive approach is to preserve natural tooth structure, control the disease process and postpone the need for restorative intervention. This is of particular importance in MIH where treatment needs often begin in childhood [1,2].

An extensive restoration is not as good as saving a MIH-affected molar before post-eruptive breakdown occurs. Therefore, early strategies of remineralization, control of hypersensitivity and protection of pits and fissures are important. The conservative restorations should strive to preserve the maximum amount of sound tissue in the presence of post-eruptive breakdown [2,5,12].

Treatment planning considerations include the lesion severity, the tooth's eruption status, hypersensitivity, caries risk, patient age and cooperation level, and esthetic expectations. Thus, there is no single treatment protocol applicable to all patients with MIH [1,5,24].

4. REMINERALIZATION STRATEGIES FLUORIDE ON SKIN

Topical fluoride

Topical fluoride is one of the most commonly used preventive methods for MIH affected teeth. The main objectives are to reduce demineralization, increase surface remineralization and enhance resistance to the development of caries. Fluoride varnishes can also be used to help control hypersensitivity [1,7].

Restrepo et al. [7] studied the remineralization of MIH-affected anterior teeth by fluoride varnish. However, MIH is a developmental mineralization defect and fluoride administration cannot completely convert hypomineralised enamel into normal enamel. Instead, fluoride should be seen as an adjunctive therapy which helps to maintain existing tooth structure and reduce caries risk[7,17].

In addition to the professional applications of fluoride, the use of fluoride toothpaste of an appropriate age group and maintenance of proper oral hygiene are important parts of MIH management [1,2].

CPP-ACP

Casein phosphopeptide-amorphouscalcium phosphate is another non-invasive agent used for remineralization and control of hypersensitivity in MIH. It is believed that CPP-ACP stabilizes calcium and phosphate ions and functions as a bioavailable mineral reservoir on the enamel surface [9,11].

Clinical improvements have been reported in MIH-affected teeth treated with CPP-ACP in a pilot study by Ozgül et al. [9]. Caruso et al. also showed that CPP-ACP application could be of benefit in children [11]. Recent systematic reviews have shown that CPP-ACP is a promising agent particularly in remineralization and sensitivity control [17,25]. However, there is a variation in study methodology making it difficult to establish a definitive standardized protocol.

The success of the treatment depends on the child's and parents' compliance, since some CPP-ACP-containing products can also be used at home. Also, since CPP-ACP is derived from milk protein, care must be taken in patients with milk protein allergy.

Products containing hydroxyapatite

Hydroxyapatite is the primary mineral component of natural enamel. Products containing nano-hydroxyapatite are believed to promote mineral deposition on hypomineralized surfaces and may help to reduce sensitivity by promoting the occlusion of dentinal tubules. However, long-term clinical evidence on MIH specifically is still limited [13,17].

Thus, products containing hydroxyapatite should be viewed as supportive, but not a substitute for fluoride and other proven preventive measures [12,13].

5. MANAGEMENT OF HYPERSENSITIVITY

Hypersensitivity is one of the most problematic symptoms of MIH for children. Pain can be caused by cold water, cold air, mechanical contact, or toothbrushing. This sensitivity can make the child reluctant to brush the area, leading to increased plaque accumulation and risk of caries [1,8].

In MIH, hypersensitivity is not believed to be solely dependent on dentin exposure. Porous hypomineralized enamel may also allow passage of thermal and chemical stimuli and passage of bacterial products toward the pulp-dentin complex which may also lead to the development of sensitivity [3,4].

Hypersensitivity is managed with fluoride varnishes, CPP-ACP, arginine-calcium carbonate, hydroxyapatite containing products and the variety of desensitizing materials. According to Bekes et al., products containing 8% arginine and calcium carbonate were reported to reduce hypersensitivity in molars affected by MIH [8].

Several desensitizing agents have been shown to produce favorable results in recent systematic reviews; however, no one agent has been shown to be definitively superior owing to differences in treatment protocols and methods of pain assessment [17,18,21].

Thus, the treatment should be individualized according to the patient's sensitivity and clinical condition.

6. APPLICATION OF A FISSURE SEALANT

Fissure sealants are an important minimally invasive treatment option for MIH-affected permanent first molars that maintain surface integrity. The goal is to seal pits and fissures physically, reduce plaque retention and protect the weakened enamel from mechanical and chemical challenges in the oral environment [2,10].

Fragelli et al. in an 18-month clinical follow-up study, showed the feasibility of fissure sealants in molars affected by MIH [10]. More recent studies also support the potential importance of fissure protection for caries control in MIH-affected molars [15] Resin-based sealants may be subject to loss of retention due to changes in the adhesive properties of hypomineralized enamel. Glass ionomer-based materials can be used for temporary protection in cases where the tooth has not completely erupted and it is hard to manage moisture. Resin based fissure sealants may be preferred in fully erupted teeth where isolation is possible [1,2,12]. Regular follow-up of molars affected by MIH and treated with fissure sealants is important. Partial loss of the material may occur, in which case repair or reapplication may be necessary to maintain the preventive effect [10,15].

7. RESIN INFILTRATION

Resin infiltration is a microinvasive therapy that has gained increasing interest in recent years for the treatment of esthetic opacities, especially in incisors affected by MIH. The main purpose of the technique is to allow a low viscosity resin to penetrate into the microporous areas of hypomineralized enamel [16,22].

The differences in the refraction of light between the porous areas of MIH lesions and the surrounding sound enamel are important for the opaque appearance of these lesions. Filling of porous areas with resin can reduce this optical difference and make the lesion less visible [16].

One of the main advantages of resin infiltration is that it requires little mechanical preparation. It can therefore offer esthetic improvement and at the same time preserve sound labial enamel, especially in young patients. In 2024, a systematic review and meta-analysis reported positive results for resin infiltration for color masking of anterior MIH lesions [16]. Not all lesions respond in the same way, however. Superficial white-cream lesions may be more predictable, but deep yellow-brown lesions may be more difficult to mask completely. Also, a relatively dense surface layer of MIH lesions may hamper resin penetration into the deeper areas. Thus, modified protocols with prolonged or multiple etching and deproteinization are being investigated [22].

8. MICROABRASION AND COMBINED ESTHETIC APPROACHES

Microabrasion is a conservative method and it can be used especially for superficial anterior MIH opacities. It consists of the controlled application of an acid and an abrasive material to remove a very thin superficial layer of enamel and to reduce color differences [1,2].

However, the results of using microabrasion alone may be satisfactory in superficial white-cream lesions, but it is limited in deep yellow-brown lesions. The advantage of the technique, being minimally invasive, is lost if a large amount of enamel would have to be removed. Thus, for deeper lesions, resin infiltration or limited composite applications may be preferred [2,12]. In selected cases microabrasion can be combined with resin infiltration. The proposed method allows to reduce the thickness of the surface layer and to ensure infiltration of the infiltrant into deeper areas [16, 22].

9. SILVER DIAMINE FLUORIDE AND SMART

Silver diamine fluoride is a noninvasive material, primarily used for the management of active dentinal caries. SDF can play a role in arrest of caries progression because of antimicrobial activity of silver ions and remineralizing action of fluoride. However, as MIH in itself is not a carious lesion, SDF is not routinely applied on all hypomineralized surfaces [19,24]. In MIH, the most relevant indications for SDF are cases in which post-eruptive breakdown and active caries coexist, especially in children with limited cooperation or marked hypersensitivity. In these patients SDF can be used to control disease activity until further extensive restorative treatment can be provided [19].

The most important disadvantage of SDF is dark discoloration in active carious tissue. This can be a significant esthetic concern, especially in the anterior.

In the Silver Modified Atraumatic Restorative Treatment (SMART) strategy, the SDF application is usually followed by the overlay of the area with a glass ionomer based restorative material. Thus, a tissue-preserving restoration and the control of caries activity are combined in the same treatment approach [19,20].

Recent clinical studies on application of SMART in permanent first molars affected by MIH have shown promising results [19,20]. However, the evidence related to MIH is limited in the long term, therefore SMART should not be considered as a replacement of conventional restorative treatment in every case of MIH.

10. CONSERVATIVE RESTORATIVE TREATMENTS

If enamel breaks down and cavitates after eruption, non-invasive therapy alone may not be enough. In such cases, the minimally invasive approach entails removing the minimum amount of tooth structure possible and placing the restoration margins on

mechanically sound tissue [2, 12].

Glass ionomer cements may be particularly useful in newly erupted MIH affected molars because of their chemical adhesion, fluoride release and relative tolerance to moisture. However, their lower mechanical strength than composite resins may be a limitation in large occlusal restorations [12,23].

Composite resins may be a more long-term option where adequate isolation can be achieved and restoration margins can be placed on sufficiently sound enamel. Note that adhesive bonding may be less predictable than on sound enamel because of the higher organic content of MIH-affected enamel [3,4].

Clinical studies evaluating direct and indirect composite restorations in MIH-affected permanent molars indicate that conservative restorative approaches can be utilized when an appropriate case selection and effective isolation are achieved [14]. In addition, the potential use of glass hybrid materials in MIH management has been investigated in recent studies [23].

11. IMPORTANCE OF FOLLOW UP AND HOME CARE

The clinical condition of a MIH-affected tooth can change over time, so regular follow-up is an important element of minimally invasive management. A molar that initially presents only with an opacity may develop post-eruptive breakdown [1,6]. Follow up visits should assess for hypersensitivity, new areas of enamel loss, caries development, retention of fissure sealants and integrity of existing restorations. For newly erupted and high-risk MIH-affected molars, closer follow-up is especially recommended [1,2,24].

Home care also directly affects the success of the treatment. The importance of regular use of appropriate fluoride toothpaste, efficient cleaning with a soft toothbrush and reduction in frequent sugar intake. Sensitivity should be addressed early on, as avoiding brushing of hypersensitive teeth may lead to increased plaque accumulation [1,21].

DISCUSSION

Current MIH management emphasizes early diagnosis and consideration of all preventive options before proceeding to restorative procedures. However, minimally invasive does not mean that in every patient only non-invasive materials are to be used. In cases of post-eruptive breakdown or caries, restorative treatment may be needed and in these situations minimally invasive care is about saving as much sound tissue as possible [1,2,12].

Remineralization and management of hypersensitivity are achieved with fluoride, CPP-ACP, Hydroxyapatite and various desensitizing agents. Although many studies have reported favorable clinical results with these products, differences in application protocols and outcome assessment methods hamper direct comparisons [17,21,25]. The present evidence does not prove that a remineralizing agent is superior to the others in all the cases of MIH.

Fissure sealants are an important preventive measure that can postpone the onset of the restorative cycle in molars without post-eruptive breakdown. However, regular follow-up is necessary as bonding to MIH affected enamel may be compromised [10,15].

One of the most important recent minimally invasive procedures for MIH anterior lesions is resin infiltration. It is a major advantage in properly selected cases [16] to be able to provide esthetic improvement without extensive composite restoration. However, deep and brown lesions may have less predictable results, highlighting the significance of careful case selection [16,22].

SDF and SMART are more recently investigated approaches for MIH management. They may offer short, tissue-preserving treatment options especially for molars complicated by caries in children with limited cooperation and marked hypersensitivity [19,20]. However, further randomized controlled trials are required to evaluate their long-term efficacy, especially in MIH.

Recent large evaluations also indicate that treatment of MIH should be staged according to the severity of the lesion. At present, the most reasonable approach seems to be preventive therapies in the early stages, microinvasive techniques in the more advanced cases, and conservative restorations when necessary [2,12,24].

CONCLUSION

Molar-incisor hypomineralisation is a major developmental enamel defect that can cause hypersensitivity, post-eruptive enamel breakdown, caries and esthetic problems in children. Successful management requires early diagnosis and regular follow-up [1,24].

In today's minimally invasive management, fluoride, CPP-ACP and other remineralizing agents may be used especially when surface integrity is preserved. Fissure sealants constitute an important option for the protection of molars affected by MIH, while resin infiltration has appeared as a tissue-preserving treatment for esthetic opacities, particularly in anterior teeth [10,16,17].

SDF and SMART are contemporary options that may be useful in selected cases, particularly when active caries is present and patient cooperation is limited [19,20]. In more advanced cases of post-eruptive breakdown, conservative restorative treatment with glass ionomer, glass hybrid or composite resin materials may be required [14,23].

To summarize, there is no single material or technique for the best management of MIH. The best approach is an individualized treatment plan that moves from preventive care to conservative restorative treatment depending on lesion severity, hypersensitivity, caries risk, tooth eruption status, and the patient's age and level of cooperation [1,2,24].

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