Contemporary management options for molar incisor hypomineralisation

Précis

Management of molar incisor hypomineralisation (MIH) in children is challenging and dentists need to be aware of a wide range of contemporary treatment options.

Abstract

Background: Molar incisor hypomineralisation (MIH) is a well-known and prevalent qualitative enamel defect, which can carry a heavy treatment burden for many patients. Early identification of MIH is paramount in order to instigate preventive regimes and potentially spare children from the restorative cycle many endure. Once enamel breakdown occurs management is challenging, as all cases present different individual considerations, from behaviour management issues to restorative decisions. The aim of this article was to review the recent literature on MIH in order to give the reader an update on contemporary management options for MIH-affected molars and incisors, and their evidence base.

Conclusion: Effective management can be very difficult for the clinician and there are limited treatment guidelines available. The individual needs of the patient will often dictate the most appropriate management and therefore clinicians need to be aware of all available options.

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DEFINITIONS AND KEY POINTS

- Molar incisor hypomineralisation (MIH) is enamel hypomineralisation of systemic origin of one to four first permanent molars (FPMs) and frequently involving the incisors.[1]
- The hypomineralised enamel is soft and porous, can sustain rapid post-eruptive breakdown (PEB) under occlusal forces, and often becomes symptomatic. As a result of these factors, these children are at a significantly high caries risk.

Background

Molar incisor hypomineralisation (MIH) is a well-recognised qualitative defect of enamel affecting one to four first permanent molars (FPMs) and frequently involving the incisors.[1] The condition is common, with an estimated global prevalence of 14.2%.[2] A recent systematic review emphasised the magnitude of the MIH burden, estimating that 878 million people across the world are currently affected, with 17.5 million new cases identified each year.[3] More severe forms of MIH carry with them a heavy treatment burden for many patients, which can negatively impact on a child's quality of life and socio-psychological status.[3] The child is often very young at the time of diagnosis, and it may coincide with their first experience of dentistry. Molars affected by MIH are often hypersensitive and therefore difficult for the child to brush effectively.[4] The hypomineralised enamel is soft and porous, often sustains rapid post-eruptive breakdown (PEB) under occlusal forces, and often becomes symptomatic.[5] As a result of these factors, these children are at a significantly high caries risk.[6] Along with increased treatment needs, children with MIH also

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FIGURE 1: Hypomineralised first permanent molar with post-eruptive breakdown of enamel (tooth 46).

Table 1: Existing MIH management recommendations.

Region	Author, year	Title
Australia	William *et al*., 2006	MIH: review and recommendations for clinical management
USA	Mathu-Muju, 2006	Diagnosis and treatment of MIH
Europe	Lygidakis, 2010a	EAPD Best Clinical Practice Guidance
Europe	Lygidakis, 2010b	Treatment modalities for children affected by MIH: a systematic review
Europe	Elhennawy and Schwendicke, 2016	Managing MIH: a systematic review

experience increased treatment time and the need for retreatments. By the age of nine, children with MIH-affected molars reportedly undergo treatment 10 times more frequently than those with unaffected molars,[7] and this, unsurprisingly, may lead to the development of dental fear and behaviour management issues, which further complicate management.[7] Early identification of MIH is paramount in order to instigate prevention regimes and potentially spare children from the restorative cycle many endure.[4] Once MIH is diagnosed, children should be recalled regularly as part of a high caries risk prevention regime,[8] thus minimising the potential for enamel breakdown. Once breakdown occurs; however, effective management of MIH is difficult, and for the treating dentist basic decision-making with regard to cavity design and material choices can be challenging. The cavities are atypical in shape and location (**Figure 1**), and this can limit the success of conventional approaches.[5] A number of recent studies have examined dentists' knowledge and perception regarding MIH management and reported disparity between clinicians' treatment decisions.[9-11] One study reported that dentists' decisions regarding cavity design and material choices were vastly different even in the same case scenario.[9] The inconsistency between practitioners is no doubt a reflection of the challenging management issues that MIH presents, and many of the studies recommended the provision of continuing education and contemporary treatment guidelines in order to address this.[9-11]

Management

A limited number of MIH management recommendations and guidelines have been proposed (**Table 1**). The most familiar guideline is the Best Clinical Practice Guidance from the European Academy of Paediatric Dentistry (EAPD).[5] This document provides a diagrammatic summary of suggested treatment modalities according to MIH severity and patient age. However, the authors highlight that ideal management is not always possible due to inherent issues with behaviour management; therefore, alternative treatment options may need to be considered.[5] More recently, a systematic review examined the evidence for various MIH treatment options and concluded that there is currently insufficient evidence for strong recommendations.[4] Instead, it was recommended that dentists consider the status of each tooth individually, along with the specific needs of the patient, when deciding how to manage MIH. Sometimes the ideal treatment for the tooth is not the ideal treatment for the patient; as a consequence, dentists who are managing MIH need to be well versed in a range of contemporary treatment options and also need to be aware of the underlying evidence base.

Desensitisation, remineralisation and prevention for MIH

Hypersensitivity is a common complaint in children with MIH and often this is a fundamental issue to address in order for the child to tolerate further treatment.[4] Even intact teeth can be exquisitely sensitive due to the increased innervation in the pulp horn beneath resulting in chronic inflammatory changes.[12] The most commonly used desensitising techniques include casein phosphopeptide-amorphous calcium phosphate (CPP-ACP), fluoride and fissure sealants.

GC Tooth Mousse contains CPP-ACP, a milk-derived protein with bioavailable calcium and phosphate. It works by creating a supersaturated environment of calcium and phosphate on the enamel surface.[13] Tooth mousse is available with or without added fluoride (900ppm), and both have been shown to enhance mineral content and reduce enamel porosity.[14] Currently, there is no evidence to recommend one over the other.[4,15] For incisors, treatment with CPP-ACP for only one month was found to reduce hypersensitivity more than fluoride varnish.[15]

The recommended protocol involves CPP-ACP application either directly to the tooth or using a custom-made medicament tray for two hours per day for a three-month period.[16] This technique is most effective if applied to the tooth as early as possible in the post-eruptive stage, before final enamel maturation takes place and the enamel surface layer becomes highly mineralised.[5] The possibility of 'maturing' hypomineralised molar enamel with CPP-ACP has been found *in vitro*, which is an exciting potential method for managing MIH; however, the recommendation is dependent upon further research.[14] There is anecdotal evidence that it also improves the appearance of the opacities. A clinical study found CPP-ACP to have a positive effect in reducing hypomineralisation *in vivo* in molars after one month of application.[17] Regarding molar sensitivity, another recent study found that the use of tooth mousse significantly reduced sensitivity in molars, when used in a custom tray for two hours a day for three months;[18] however, the sample size was small. While further work is needed to establish the value of CPP-ACP, the possibility of sparing the patient the cycle of repeated restorative interventions is promising.[19,20]

Regarding fluoride varnish (FV), the most commonly used and well-researched topical preparations contain 22,600ppm F (e.g., Profluorid and Duraphat).[21]

FIGURE 2: Hypomineralised teeth 36 and 46 with well-placed GIC fissure sealants. Note the demarcated opacities on the mesial occlusal surfaces with PEB on the mesio-buccal cusp.

While FV may be helpful in combatting sensitivity, there is insufficient evidence relating to its effectiveness on MIH teeth to date, and further work is needed to evaluate its benefit.[4,5] Another option to manage this issue is densensitising toothpastes. One study found that 8% arginine (ProArgin Elmex 1,450ppm F toothpaste) improved sensitivity in molars over an eight-week period;[22] however, the study evaluated a small sample. Despite these promising results, further studies are needed to clarify their efficacy.

Silver diamine fluoride (SDF) has gained recent popularity and is currently licensed as a desensitising agent (e.g., SDI's Riva Star). It reduces the growth of cariogenic bacteria, inhibits demineralisation and promotes remineralisation.[23] It is a non-invasive and cost-effective treatment, is most commonly available in a 38% SDF preparation and, when applied to carious dentine, causes a permanent black discolouration.[24] However, despite the theory that it would help MIH, the authors couldn't find any study relating the two factors. This would be interesting for further research, especially given the recent popularity of SDF.

The use of fissure sealants (FS) in MIH molars is crucial both to manage sensitivity and prevent enamel breakdown.[5] Glass-ionomer cements (GICs) can be used as interim treatments where the molar is partially erupted or the tooth is hypersensitive with a view to placing resin-based FS in the longer term.[5] One study found that GC Fuji Triage had the highest fluoride content compared to a number of available glass-ionomer products,[25] and is ideal for use as an interim FS in a sensitive MIH molar (**Figure 2**). Resin sealants often have unpredictable longevity in hypomineralised teeth due to difficulty with adhesion.[4] However, one study comparing resin sealants on MIH-affected and unaffected molars found similar survival rates on both groups even without bonding, although the sealants were placed under ideal conditions (rubber dam isolation with local anaesthesia).[26] A systematic review concluded that, overall, bonded resin sealants have been shown to have better retention than non-bonded resin sealants in MIH molars.[27] Using a fifth-generation adhesive system has been shown to improve FS retention in one long-term study.[28] It has also been suggested that using flowable composite can increase retention in molars affected by MIH.[29]

There have been suggestions to pre-treat the hypomineralised enamel with sodium hypochlorite (NaOCl) to overcome the irregular etching pattern observed, as pre-treating with NaOCl could theoretically remove the intrinsic protein that interferes with bonding.[30] However, a randomised controlled trial (RCT) on extracted MIH molars found no advantage to using this technique[31] and further research is needed.

FIGURE 3a: Hypomineralised opacities on teeth 11 and 21 before treatment with micorabrasion.

FIGURE 3b: Teeth 11 and 21 after treatment with micorabrasion.

Pain control – how can I manage anaesthesia?

MIH molars can be more difficult to anaesthetise effectively with standard local anaesthetic (LA) agents due to increased innervation density in the pulp and chronic pulpal inflammation.[32] It is important to remember that traditional signs of effective anaesthesia, such as numbness of the soft tissues, may not actually equate to effective pulpal anaesthesia in MIH molars.[33] Some authors have advocated the use of the electric pulp tester to additionally verify anaesthesia of a tooth prior to commencing treatment.[33]

Different choices of anaesthetic are available (i.e., 2% lidocaine, 3% mepivacaine, and 4% articaine). There are very few studies examining the efficacy of local anaesthesia specifically in MIH teeth and further research is needed in this area. A systematic review suggested that while dentists may be tempted to increase the dose of anaesthetic to compensate for a hypersensitive tooth, the type and dose of anaesthetic are not as important as the adjunctive techniques used to achieve anaesthesia.[33] One study recommended that accompanying a lidocaine inferior alveolar nerve block with a supplementary buccal infiltration with 4% articaine was more likely to allow pain-free treatment in lower molars with irreversible pulpitis.[34] While this study didn't examine molars with MIH specifically, the findings could be extrapolated for MIH molars, which may also demonstrate pulpal inflammation. It is important to be mindful of dose limits in paediatric patients for all anaesthetic agents, but especially when using articaine 4%.[34]

The use of periodontal ligament (PDL) injections has been suggested as an adjunct to block or infiltration anaesthesia.[33] However, it must be used with caution in an already compromised tooth as it has been suggested that the

FIGURE 4a: Hypomineralised opacities on teeth 11 and 21 before treatment. Note the demarcated enamel opacities (white/yellow and brown areas).

FIGURE 4b: Teeth 11 and 21 post treatment with a combination of microabrasion and composite resin.

force of injection in combination with the vasoconstrictor may further compromise the condition of an already inflamed hypomineralised molar pulp.[12,33] More recently, there has been focus on the use of intra-osseous injections in MIH, and some authors have reported significant improvements in anaesthesia.[33,35,36] However, despite these promising results, these anaesthetic techniques have not been widely adopted in general practice. The use of pre-emptive analgesia (using ibuprofen) has also been suggested to alleviate pain during treatment and increase the effectiveness of local anaesthetics.[33] While theoretically anti-inflammatories could reduce symptoms of chronic inflammation, there is no evidence for the efficacy of pre-emptive analgesia in MIH. Finally, nitrous oxide inhalational sedation is a popular and effective adjunct to LA to combat hypersensitivity in children with MIH.[37]

Managing incisors

Hypomineralised incisor opacities can range in colour from white to creamy/yellow or brown, the colour a reflection of hypomineralisation severity.[38] Defects usually present on the buccal surfaces, and PEB is unusual but not impossible. Timing of any intervention depends on the individual's aesthetic complaint, which should preferably come from the child themselves rather than the parent. Any treatment other than remineralisation should ideally be delayed until the defect is fully erupted in the mouth, as mineral content can improve after eruption into the oral environment,[39] and therefore the enamel opacities can be less profound in the long term.[40] When managing incisor opacities, a conservative treatment approach is essential, especially in a young tooth with immature root formation and a large pulp.[5] Recommended minimally invasive treatment techniques, which can be used alone or in combination, include CPP-ACP (tooth mousse), enamel microabrasion, the etch bleach seal technique, and resin infiltration.[5,15] Improvement of the visible incisor opacities in MIH using these simple, minimally invasive techniques is possible, and has been shown to have a positive impact on children's well-being.[41]

Aesthetic improvement of incisor defects using enamel microabrasion has been recommended.[4,5] Microabrasion involves the use of hydrochloric acid (HCl) in an abrasive paste, which is applied to the enamel surface in conjunction with mechanical pressure under rubber dam isolation. The procedure is repeated a number of times for 5-10 seconds with pressure and intermittent washing, removing 100-200 microns of enamel depending on the pressure used (**Figures 3a** and **3b**).[42] This action changes the visual properties of the enamel surface by forming a dense, prismless surface layer, and changes the optical properties of the surface.[42] Different concentrations of HCl are commercially available in microabrasion kits (6.6% [Opalustre; Optident], or 18% [PREMA; Premier Dental]) but 37% phosphoric acid has also been used for this technique.[37] A recent split mouth RCT comparing microabrasion using either 18% HCl or 37% phosphoric acid found a 97% reduction in opacities using either solutions.[43] Another study that examined incisor opacities of various origins found a stable improvement in 66% of teeth using 18% HCl;[42] however, microabrasion was less likely to work with full thickness defects,[42] as is often the case with darker yellow/brown-coloured MIH opacities.[5] Nonetheless, even if the defect is not completely resolved using microabrasion, it may provide some improvement, which can then be more easily masked with composite resin (**Figures 4a** and **4b**).

Another minimally invasive technique is the etch-bleach-seal technique, originally described by Wright in 2002, who reported good results for removing stained yellow-brown defects in incisors.[44] This technique involves etching the enamel surface with 37% phosphoric acid followed by application of 5% NaOCl for 5-10 minutes, re-etching and application of a clear fissure sealant over the surface.[5] More recently, resin infiltration techniques such as Icon (DMG) have been described but, according to a systematic review, further evidence is required before they can be recommended.[45] Composite resin is the material of choice for large defects that have exposed dentine with overall minimal enamel reduction.[5] Enamel bleaching is not recommended for incisors in adolescents, as it may induce hypersensitivity and mucosal irritation.[5,40] Other, more invasive treatment options should be delayed until the patient is older and eruption complete with mature gingival architecture.

Managing molars

In sound teeth, mineral density increases from the cemento-enamel junction (CEJ) to the cusp/incisal tip, while in MIH teeth mineral density drops from the CEJ to the occlusal surface.[42,46] MIH molars experience hypomineralised defects of varying severity that follow the natural incremental lines of enamel formation. The degree of discolouration is a reflection of the severity of the mineral deficit,[38] and it has been suggested that the higher the protein content, the higher the risk for PEB to occur.[47]

Restoration of MIH molars poses significant challenges due to the poor mechanical and physical properties of the affected enamel. GIC or resin-modified GIC (RMGIC) restorations may be considered only as an intermediate approach until a definitive restoration is placed due to their mechanical properties.[4,48] Amalgam should be avoided in MIH molars as it is non adhesive and, due to the atypically shaped cavities, breakdown can occur at the

FIGURE 5a: Hypomineralised first permanent molar (tooth 16) with caries and PEB. Note the enamel opacities surrounding the margins of the defect.

FIGURE 5b: Tooth 16 temporised with a GIC restoration prior to SSC placement. An orthodontic separator is placed mesial to 16 for one week to gain space and allow for a more conservative proximal reduction for the SSC.

FIGURE 5c: Tooth 16 after treatment with a stainless steel crown in place.

margins.[4] One study found that only 38% of amalgams were acceptable in MIH molars after four years compared to 75% of composites.[49] When intracoronal restorations are indicated, composite resin appears to be the most favourable.[4,37] It is the material of choice for one to two surface defects with supragingival margins.[37] However, they are highly technique sensitive and bonding of the hypomineralised enamel can be challenging.[4,50] Lygidakis (2003) reported that composite was 100% successful for two and three surface defects in severe MIH molars after four years.[51] Mejare (2005) also reported high success rates for composites in MIH (85%).[52]

A potential adjunct to improve bonding is pretreating the enamel with 5% NaOCl as mentioned previously; however, further research is needed.[50] Bonding with self-etching primer adhesives was previously recommended,[37] but recent evidence suggests that it does not offer superior bonding over total etch systems.[50,53]

Regarding intracoronal cavity design for composite resin, two main but controversial approaches have been suggested: removal of all defective enamel; or, removal of porous enamel only.[5,37] A study comparing both approaches found that failure of the restoration was higher in the group with residual hypomineralised enamel.[54] Overall, the current recommendation is to extend cavity preparations onto sound enamel (i.e., not porous, independent of tooth discolouration) since bonding to MIH enamel has not produced a steady solution to date.[37,40,50] This is an area that warrants further research, as studies that examine dentists' management of MIH show most disparity regarding cavity design.[9]

When MIH molars are severely broken down or hypersensitive, full-coverage restorations are often indicated. Preformed stainless steel crowns (SSCs) are indicated by the American Academy of Pediatric Dentistry for developmental defects or when failure of other available restorative materials is likely.[37,55] The advantages of SSCs include their durability, low cost, and the fact that they are easy to place.[37] They also prevent further breakdowns of the tooth and control sensitivity.[37] However, it is important that the patient and parent are informed about the long-term financial implications of crown placement. Although there is little data on long-term follow-up, two studies reported notable success using SSCs for MIH molars.[4] Kotsanos (2005) reported that 100% of SSCs in MIH teeth were acceptable after four years.[49] Zagdwon (2003) also found that SSCs for severely affected MIH molars had a high success rate.[56] In severe MIH, SSCs may be more cost-effective, quicker to place, and less technique sensitive than intracoronal restorations (**Figures 5a**, **5b** and **5c**).[4] Unfortunately, SSCs are still greatly underused by many general practitioners and continuing education courses are recommended in order to address this. Indirect restorations such as cast crowns or onlays for MIH molars could be used,[52,56] but they are seldom indicated in young children.[4,37]

Extraction of MIH molars

MIH teeth are commonly found to need repeated restorations, which results in further tooth structure loss.[54] For some MIH teeth, the burden of treatment is high, especially when the breakdown is advanced, and these teeth are especially challenging to treat. Very often the clinician is faced with the difficult decision to extract or try to restore a severely broken down MIH-affected FPM. There are conflicting opinions about the benefit of extracting FPMs since it is the most invasive treatment option. Advantages include elimination of the long-term restorative burden and less chance of impaction of the third molars.[57] The main disadvantage is the high need for general anaesthesia and the risk of residual spacing necessitating orthodontic management.[57,58] Despite this, it has been suggested as a good treatment option for severely affected MIH molars, if correct planning is performed, resulting in the best long-term result for the patient.[57] A very recent paper describes a useful clinical protocol for management of FPMs, including a step-by-step guide for decision-making for interceptive extractions.[59] It is important to note that when planning for interceptive extractions, the authors assume that the FPM is asymptomatic or

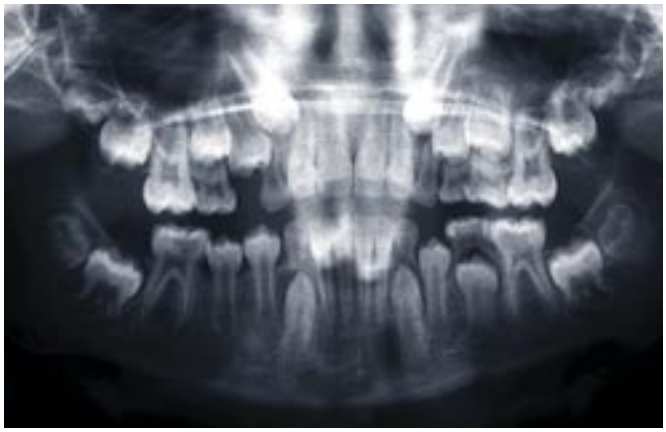

FIGURE 6: Panoramic radiograph of a patient with MIH showing extensive defects in teeth 36 and 46 occlusally. This OPG demonstrates some features that indicate the 'ideal timing' for extraction of a FPM: the bifurcation of the second molars are developing and the third molars are present.

has been stabilised.[59] Overall, the vast majority of FPMs are extracted due to caries, while extraction due to MIH accounts for only 11% of the total loss.[60] FPMs are very rarely the teeth of choice for extraction for orthodontic reasons; thus, this makes the decision on removal more difficult. The Faculty of Dental Surgery of the Royal College of Surgeons of England guidelines provide advice for extraction of FPMs of poor long-term prognosis depending on the classification of occlusion.[58] Variables surrounding the decision to extract include the severity of the MIH, the restorability of the tooth, the occlusal relationship and the dental age of the patient. The ideal time to extract the FPM is a chronological age range of 8-10 years, after the lateral incisors have erupted but before eruption of the second permanent molar, as this results in the most favourable mesial movement and space closure of the second permanent molar.[58] Earlier extractions are not recommended as the second permanent premolar may drift distally. Furthermore, late extractions are also problematic as they often result in severe mesial tipping of the second permanent molar.[57,58] Ideal timing also corresponds to a number of radiographic features (**Figure 6**). The second permanent molar should be angled mesially in relation to the FPM, and the bifurcation should show evidence of calcification.[58] The second premolar should be engaged in the bifurcation of the second primary molar and the third molar should be present.[58,61] Very often though, decisions regarding FPM extractions have to be made before presence of the third molar can be confirmed radiographically, as calcification typically only begins at age eight.[58] Some authors suggest that by age nine clinicians can usually make a decision regarding third molar presence if dental development is otherwise normal.[59] They caution about not waiting so long that the second molar erupts, as there is no benefit to an interceptive strategy once the second molar is in occlusion.[59]

It has been found that extraction of severely affected molars, with the above considerations, can result in favourable space closure by the second permanent molar in 66-87% of cases.[52,57,58] Successful space closure can even occur if FPMs are extracted after the ideal age, once the second permanent molar is still unerupted, in particular for maxillary molars.[52,57,62] However, it is important to note that there is a significant difference between upper and lower extractions. For upper extractions, 92% resulted in good space closure as opposed to only 66% of lower first molars displaying favourable results despite extraction at a perceived ideal time.[62] Compensating extractions are recommended when removing the lower FPM to avoid overeruption of the upper FPM, but the reverse is not recommended. Balancing extractions of FPMs is not recommended at all.[58] It is also not advised to remove a healthy premolar for orthodontic proposes if the molar in the same quadrant is heavily restored.[58] When deciding to extract, it is crucial that the dentist seeks an opinion from an orthodontic specialist.[30] There is a need for high-quality prospective studies on loss of FPMs to further evaluate the efficacy of extraction as a treatment option for MIH.

There are financial implications in deciding to remove a severely affected molar or to place complex restorations that require replacement over their lifespan.[63] One study found that extraction of FPMs with severe MIH has been shown to be the most cost-effective treatment option provided the extraction is carried out at the ideal time, thereby reducing the need for orthodontic treatment.[63] However, if the ideal timing has passed (i.e., after eruption of the second permanent molar), restoration with composite resin was the least costly option, especially for a single molar.[63] It should be mentioned that these results apply to a German healthcare system and may not be applicable to an Irish structure.

Conclusion

MIH is undoubtedly a significant dental public health concern worldwide given its global prevalence, and many dental practitioners will be all too familiar with its presentation and the unique challenges that it brings. Management can be difficult as all cases present different individual considerations, from behaviour management issues to restorative decisions. The clinician needs to be well versed in the range of treatment options available in order to provide optimal care for children with MIH. It would be interesting to gain insight into the perception and management of MIH among Irish dentists, and this is a recommended area of further research.

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CPD questions

To claim CPD points, go to the MEMBERS' SECTION of www.dentist.ie and answer the following questions:

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CPD

1. What is the estimated global prevalence of MIH?

- ○ A: 5.2%
- ○ B: 14.2%
- ○ C: 22.5%

2. Microabrasion is:

- ○ A: the use of phosphoric acid or hydrochloric acid in an abrasive paste, which is applied to the enamel surface in conjunction with mechanical pressure
- ○ B: the use of phosphoric acid or hydrofluoric acid in an abrasive paste, which is applied to the enamel surface in conjunction with mechanical pressure
- ○ C: the use of hydrofluoric acid or hydrochloric acid in an abrasive paste, which is applied to the enamel surface in conjunction with mechanical pressure

3. Extraction of a first permanent MIH molar at the ideal time for optimal space closure by the second molars is more predictable in the lower arch.

- ○ A: True
- ○ B: False