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Treatment Modalities for Molar Incisor Hypomineralization MIH: A Narrative Review

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Abstract

Molar incisor hypomineralization (MIH) is a clinical appearance of hypomineralization with systematic origin affecting the first permanent molars (FPMs) and usually related with hypomineralized incisors. Unfortunately, this condition affects the functions as well as the aesthetics of patients such as dental caries and post-eruptive enamel breakdown not only that, but it also creates treatment challenges to the dentists. Restorations in the cases of MIH seems to fail more often; there is few science-based literature to support clinical decisions on cavity design and material selection. The pervasiveness of MIH and the deficiency of literature regarding treatment modalities indicate the need for further researches to clarify proper guidelines for management of MIH cases and enhance the durability of restorations in affected teeth. The objective of the present study was to comprehensively review the various modalities presented in literature that were used to treat MIH in children.

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1 Introduction

Molar incisor Hypomineralization (MIH) is a developmental in origin defects affecting the enamel of permanent first molars and incisors. It is produced by insufficient mineralization and maturation. At 2001 the term of MIH was firstly introduced by Weerheijm et al. It was identified as a demarcated enamel defect ranging from white, yellow, or brown opacity to soft and porous enamel, with high risk of post-eruptive enamel breakdown (PEB). Rapid carious development is a common consequence as dentin becomes eventually exposed [1].

The prevalence of MIH has been shown to reach up to 40 % of children in certain countries. However, the defect takes variable forms, which may indicate even higher prevalence than detected [2]. The defect is qualitative in nature, caused by an insult to the ameloblast life cycle, resulting in hypomineralized enamel with lowered mechanical properties than normal, as well as higher protein content that inhibits the growth of the hydroxyapatite crystals [3]

The causative mechanism of MIH is still unclear, but the clinical presentation of localized and asymmetrical lesions suggests a systemic origin with the disruption in the amelogenesis process most probably occurring in the early maturation stage or even earlier at the late secretory phase. In general, the condition seems to be multifactorial and systemic factors such as acute or chronic illnesses or exposure to environmental pollutants during the last gestational trimester and first three years of life have been suggested as causative or contributing factors. The number of affected teeth was associated with the time when the potential systemic disturbance occurred; children with prenatal, perinatal and postnatal problems showing more affected teeth in increasing order. Multiple possible causes have been suggested in the literature, for instance, respiratory tract infections, perinatal complications, dioxins, oxygen starvation, low birth weight, calcium and phosphate metabolic disorders, frequent childhood diseases, use of antibiotics and prolonged breast feeding. In addition, some studies raise the possibility of a genetic role in the aetiology of MIH, indicating that a genetic variation may interact with systemic factors leading to MIH [4,5].

Weerheim et al. in 2001 introduced a detailed standard for defining MIH. This includes four types of defects; opacity, PEB, atypical repair and extraction with MIH. In 2003, the European Society of Pediatric Dentistry (EAPD) introduced a numerical scoring system for clinical diagnosis:

0: Normal.
1: Demarcated opacity.
2:Post-eruptive enamel breakdown.
3: Atypical restorations.
4: Extracted molar due to MIH.
5: Unerupted molar due to MIH [6].

A more descriptive diagnostic method (MIH severity scoring system (MIH-SSS)) is recreated in 2019 by Cabral et al [7], in which nine codes were given to the lesions according to severity of the defects. **Figure 1**

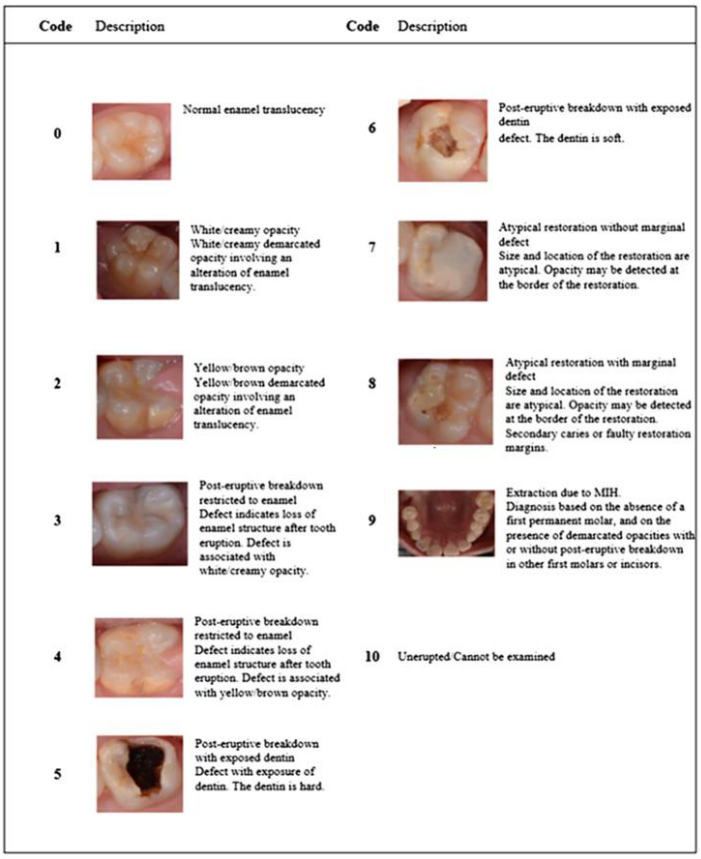

Figure 1. showing Codes of MIH-SSS and their description developed by Cabral et al. [1]

Mathu-Muju and Wright had classified MIH into three severity levels:

- **Mild MIH:** the demarcated opacities located at non-stress bearing areas, no caries associated with the affected enamel, no hypersensitivity and incisor involvement is usually mild if present.

- **Moderate MIH:** the demarcated opacities present on molars and incisors, the post-eruptive enamel breakdown limited to one or two surfaces without cuspal involvement, atypical restorations can be needed and normal dental sensitivity.

- **Severe MIH:** post-eruptive enamel breakdown, crown destruction, caries associated with affected enamel, history of dental sensitivity and aesthetic concerns [5].

Steffen et al. [8] MIH Treatment Needs Index (MIH-TNI) proposed in 2017. It provides suggestions for decision-making when planning individualized treatments for MIH-affected teeth. MIH-TNI classifies affected teeth based on the presence of

hypersensitivity and the severity of enamel lesions. Treatment plans have also been developed for people with a low or high risk of tooth decay. TNI's suggested treatments include both dental prophylaxis (fluorine varnish and crack sealing) and restorative care (filling, crown, tooth extraction).

The effect of MIH generally on health and lifestyle quality in children has been addressed in several researches. Deterioration of aesthetics due to discoloration or morphological changes leads to anxiety and social disconcerting [9]. Hypersensitivity is also a problem when looking for a cure for the condition. However, while recent studies and researches on MIH has raised awareness between dental pediatricians, there is currently no standardized treatment. The main challenge is the various clinical manifestations of diseases of varying degrees of severity and the wide range of therapeutic approaches available. Hence, the objective of this research is to shed a light on various treatment modalities and restorative options presented along the past decade.

In order to supply a comprehensive treatment for this disease, the dentist have to deal with several challenges. They can be summarized as follows:

1. Post-eruptive enamel breakdown followed by dentine exposure and subsequently pulp involvement.
2. Idiopathic tooth sensitivity followed by bad oral hygiene and as a result, caries risk increases.
3. Difficulty in administering local anesthesia which may probably be due to chronically inflamed pulp.
4. Behavioral management obstacles as a result of dental fear and anxiety associated with pain felt by patients during various appointments.
5. Aesthetic complications anteriorly
6. Loss of tooth
7. Frequent eruption problems in molars because of enamel roughness.
8. Financial concerns for families. [5]

Identification and early diagnosis of patients that might be at risk to develop MIH may lead to more effective and conservative treatment [5,10]. Currently, there are no guidelines that prove how to correctly manage MIH patient. However, EAPD published an unanimity article entitled "Best Clinical Practice Guidance for Clinicians Working with MIH" in 2010 [11]. The author acknowledged that science-based research publications regarding this disease were limited at that certain time, and suggested specific areas of need for further researches. This issue has received great alertness from scientists in recent years, but further researches into improved clinical management and preventive measures are needed and advised [9]. Eventually, the following are some management and treatment approaches proposed in the literature:

Prevention, remineralization, and sensitivity management:

It is necessary to begin improved prophylaxis once the diseased teeth with MIH erupt because they are subjected to post-eruptive enamel breakdown and dental caries due to enamel's increased porosity and poorer resistance to mechanical forces, particularly in advanced MIH lesions [10]. Diseased children and their parents are advised to have proper nutrition and preventative counselling. To minimize caries risk and tooth sensitivity, they better use toothpaste containing fluoride with minimum 1450 ppm.

Relating to various in-vivo and in-vitro studies, enhancing the mineralization of teeth with MIH after eruption is achievable; nevertheless, completely cured lesion is challenging due to the large depth and/or thickness of such lesions [5]. Usage of casein phosphopepetide amorphous calcium phosphate (CPP-ACP) containing products for long period of time to remineralize MIH teeth is suggested, particularly at early stages while the enamel is not completely matured yet [5]. By enhancing the absorption of calcium and phosphate that's present in saliva, the CPP-ACP ingredient stimulates remineralization and also desensitisation of affected teeth.[10,11] The ability of CPP-ACP to create a strong bond with the biofilm present on teeth, as well as assisting fluoride ions and calcium phosphate in saliva, preventing spontaneous accumulation, and allowing these ions to penetrate deeper. All those factors are efficient in enhancing the remineralization process throughout the lesion, while products containing fluoride only primarily remineralize the layer of the surface.

Dentists should be aware that due to the presence of casein, CPP-ACP products are not recommended for children having allergy from milk

protein [5]. Sugarless chewing gum and CPP-ACP lozenges are effective and is advised [10,12]. Usage of tooth mousse for four months improved tooth sensitivity in MIH teeth, and hence these products can be prescribed to individuals who experience mild pain from external stimulation according to Pasini et al.

Sealing the fissures of MIH molars is indicated at the dental clinic as part of preventive measures. Resin-based fissure sealants with adhesive application before placement can be employed to promote fissure sealant retention if enamel surface of MIH tooth is intact [5,10]. According to certain studies, they recommended that treating the defective enamel first with sodium hypochlorite in concentration of 5% or the papain-based papacarie gel in duration of 60 seconds as a deproteinizing agents before etching will dramatically boosts bond strength [13]. Application of fissure sealant incorporated with glass ionomer cement is recommended to manage MIH molars suffer from hypersensitivity or exhibit post-eruptive enamel breakdown or even partially erupted [10,11]. They will function as a temporary treatment alternative because retention of this material is low. The goal is different from that of traditional fissure sealants. Up to the cusp level, covering the occlusal surface completely with glass ionomer cement, flowable or filled composite is frequently requested. In general, the applied fissure sealants are checked on a regular basis and replaced as needed [11]. Furthermore, as part of the preventive measures and to lessen tooth sensitivity, patients should have frequent applications of fluoride varnishes/gels provided by the dentist [10].

2. Restoration of molars

Researchers predicted that MIH teeth need 5-10 times the amount of dental care compared to molars without MIH. The initial clinical concern in handling these teeth is whether to repair or extract. This is determined by parameters as the age of the child, the restorability of the tooth/teeth, the severity of MIH, pulp involvement, the existence of third molar germ(s), the anticipated eternal prognosis, and the expense of life-long therapy. [11]

3. Resin infiltration

It is called erosion-infiltration, it employs a resin with low viscosity that's able to pass the demineralized enamel. Because of MIH, the enamel is very porous and has a decreased mineral density thus, they are more susceptible to this low viscosity resin material's penetration. The sole material accessible for such process is ICON by DMG (Hamburg, Germany). Because this product lacks bioactive qualities, it cannot be used for mineral boosting of the lesion. It was hypothesized that it creates defense against acid attack and enamel hardness increased by approximately 15%. Moreover, this material is able to invade surfaces such as hypomineralization in inclination of cusps and consequently reducing post-eruptive enamel breakdown; with good isolation, it might be efficient as fissure sealant as well. [5,14]

An in-vitro study investigating the ability of the resin infiltration (RI) to penetrate MIH enamel lesion made by Crombie et al. in 2013 and they concluded that RI if applied before composite restoration can be efficiently enhance bonding by increasing the hydrophobicity of the surface and the surface area of resin-enamel terminal and they recommend further investigations regarding MIH management applications and to predict if these theoretical information might be applicable in clinical cases. [15]

Kumar et al. in 2016 were investigating the effect of the RI on the micromechanical properties of hypomineralized enamel and found that RI cannot be considered as clinical procedure in treating severe MIH cases. The contrary seemed to be correct, by increasing the etching time in treating mild MIH cases would be effective. They ended up by recommending further investigations to well know the physical, chemical, and micromechanical properties of hypomineralized enamel lesions. [16]

Denis et al. in 2013 found that treating mild MIH cases with RI was clinically insignificant as the defect in located underneath of relatively healthy enamel below the superficial two third. Consequently, further studies and investigations are recommended in this area and this technique could not be strongly supported. [14]

4. Restorations

Dentists commonly struggle to outline the cavity margins while treating hypomineralized teeth. Cavity design is very critical because defective enamel remnants affect the overall outcome. When identifying the placement of the cavity margin, two approaches are described:

1. All defective enamel is removed
2. Porous enamel only is removed, until feeling good resistance of the bur [17].

The former approach may prevent early failure of the restoration but compromises tooth surface; the later method is better in conserving tooth structure but restorations might be subjected to marginal disintegration as a result of weak bond strength between resin adhesives and hypomineralized enamel, it is suggested that before applying resin composite restorations to hypomineralized PFMs [18] all deficient enamel should be removed .

Choosing the materials to be used depend on the lesion's severity in the first place, as well as the cooperation and the age of the child. Restorative choices are glass ionomer cements (GIC), resin-modified glass ionomer cements (RMGIC), polyacid modified resin composites (PMRC), resin composites (RC), and amalgam.

Amalgam considered as an excluded option due to:

1. Poor retention if prepared cavity is shallow.

2. Difficulty in maintaining residual tooth structure, which is likely lead to restorative failure [17].

Because of the atypical cavity outlines that result from the removal of hypomineralized enamel, adhesive materials are often employed. For dentine displacing or as temporary restoration, GIC allows application easily, release of fluoride, and bond chemically to the tooth structure. The addition of photoinitiators besides resin in RMGICs enhances handling of the material, resistance to wear, fracture toughness, as well as fracture resistance. RMGIC or GIC restorations are not recommended in stress-bearing areas, as hypomineralized molar occlusal surfaces, but is added until a final restoration is achieved [17].

RC has better physical properties than GIC and RMGIC and is an aesthetic material with excellent wear resistance and adhesion when used in combination with resin-based adhesives. They can be used alone or in a sandwich approach after prior transient treatment with GIC. However, RC is technique sensitive and requires proper moisture control and long storage periods under rubber dams [21]. RC is the recommended material for MIH when defective enamel is clearly defined and is confined to one or two surfaces without the involvement of cusps. After all defective enamel was removed, RC-affected recovery of PFM was clinically effective for 4 years.

In comparison, the PMRCs characterized by having superior handling properties, the ability to release and recharge fluoride and having superior flexural and tensile strength properties to that of RMGIC and GIC, but lower to that of RC [17]. PMRCs are only used in nonstress-bearing areas of permanent teeth, with limited applicability in hypomineralized PFMs [19,20].

5. Adhesion to hypomineralized enamel

The reduced mineral concentration and high protein content in the hypomineralized enamel hinder efficient etching and bonding. It has been recommended that enamel could be pretreated with sodium hypochlorite in 5% to eliminate the protein around the hydroxyapatite. It is also advised that all hypomineralized enamel should be removed before applying RC restorations. The deficient literature related to bonding to hypomineralized enamel as a result of lack of removed hypomineralized teeth having adequate surfaces for bond strength testing [17].

Bond strengths of RC to hypomineralized enamel of PFMs with MIH are much lower than bond strengths to normal enamel for single-bottle total etch and self-etching primer adhesives. Williams et al. in 2005 conducted an in-vitro study showed that the mean microshear bond strengths (MPa) of resin composite bonded to hypomineralized enamel were substantially lower than for control enamel. Scanning electron microscopy of hypomineralized enamel after

phosphoric acid etching revealed that within the enamel prisms, there are interprismatic spaces and very little intercrystal porosity, allowing for little microtag development (which is essential for the bonding efficacy of single-bottle, total-etch adhesive systems) and flaws that might contribute to crack propagation within the enamel. Eventually, RC is advised for reconstructing molar surfaces with minimum involvement. Following the removal of any discolored hypomineralized enamel, cavity borders should be put on presumably sound enamel and RC bonded using a self-etching primer adhesive. Due to the weak adherence of RC to hypomineralized enamel, marginal placement should be performed on seemingly sound enamel [18].

6. Full coronal coverage restorations

Preformed stainless steel crowns (SSCs) maybe the treatment of choice for PFMs with moderate to severe PEB. These crowns prevent further tooth degradation and manage tooth sensitivity, establish proper adjacent interdental contact and occlusal relationships, are less technically-sensitive and less expensive than cast restorations, and it takes little time to prepare. However, SSCs can cause open bites, gingival inflammation, or both if not properly adapted. Probably placed, SSCs can preserve PFMs with MIH until cast restorations are achievable.

In late mixed and permanent dentitions, partial and full coverage indirect adhesive or cast crowns and onlays may be recommended for MIH. Due to the placement challenges that will face the dentists associated with the anatomy of the newly erupted permanent teeth such as large pulp horns and relatively short crowns, cooperation status of the child and lengthy appointments and raising expenses, such restorations are rarely recommended for PFMs in young children [17]. However, the use of laboratory-fabricated crowns of cast gold, indirect composite, and ceramic in 6 to 8 years old children has been regarded as clinically highly effective throughout a 2 to 5 years follow-up period. Cast restorations provide the following advantages over SSCs:

1. Need limited tooth preparation.
2. Decreased pulpal trauma.
3. Preserve the remaining tooth structure.
4. Enhance strength for cuspal overlays.
5. Effectively manage sensitivity of tooth
6. Promote periodontal health as their margins are supragingival [17].

Others claim that there is no dissimilarity in the quality or durability between cast adhesive copings and prefabricated SSCs. Therefore, whether to replace the hypomineralized PFMs with copings or prefabricated SSCs is determined by the following factors:

1. Demands of the patients.
2. Cooperation status.
3. Treatment expenses.
4. The experience of the clinician [17]

7. Extraction of severely affected molars

Extraction may be recommended for severely compromised FPMs with a poor prognosis at the dental age of 8-10 years. This will allow the 2nd permanent molars (SPMs) to migrate to the FPMs position. Before extracting the molars, a comprehensive dental examination should be performed to assess the presence, location, and proper formation of the growing permanent dentition in order to ensure good orthodontic conditions. As a result, it is critical to refer to orthodontist before extraction, and subsequent FPM extractions may be considered for balance and compensatory purposes. [21]

If the SPM follicle is still fully inside bone, automatic mesial eruption may occur commonly. It has been proposed that the calcification of the bifurcation of the roots of the lower SPMs radiographically shows the exact timing of FPM extraction. However, research shows that the development phase of SPM development may not be as important as the current recommendations predicts. The probability of optimal placement of SPMs after extracting FPMs at optimal times is 94% for higher SPMs and 66% for lower SPMs. In the maxilla, complete gap closure can be expected regardless of the time of tooth extraction, but in the mandible, a significant proportion of patients will have FPM extracted at a time generally considered ideal. It still has an incomplete gap closure. Tooth misalignment. As a result, fixed orthodontic

treatment may be required to reduce the remaining gap, which takes less time than performing an FPM extraction after an SPM eruption [22].

8. Restoration for incisors

Aesthetic problems that affect incisors are common in patients with MIH. In reference to the age, these patients have immature anterior teeth with large and delicate pulps and need to be treated conservatively. Therefore, it is advisable to postpone the cosmetological treatment as the opacity of the enamel often become less noticeable over time. In general, yellow-white defects are less severe than yellow-brown defects, and incisor defects are milder than molar defects,but incisor defects tend to collapse more posteriorly than labially which makes it clinically difficult to be treated. There are various treatment options for anterior teeth with MIH that might be done alone or in combination to obtain superior aesthetic outcomes. [5,10]

9. Microabrasion

This is associated with the removal of small amounts of surface enamel (100 μm (0.1 mm or less)) due to wear and erosion [23]. The technique grinds and polishes the surface enamel, resulting in altered in optical properties and improved aesthetics. The pathological anatomy of MIH lesions suggests microwear when staining is confined to the outer surface of the enamel and may be valuable when used alone. [5]

10. Tooth bleaching

The goal is to hide the whitish opacities by brightening all teeth as a whole [14]. This choice is recommended for adolescents [10]. Bleaching can cause sensitivity, mucosal irritation, and changes to the surface of the enamel. [11] Home bleaching using 10% carbamide peroxide gel in customized trays is the safest bleaching alternative advised by the dentist, however for further safety, a combination of CPP-ACP Mousse and bleaching gel is advised. The CPP-ACP Tooth Mousse will preserve the tooth structure and remineralize the MIH opacities without affecting the bleaching reaction. The ratio of hydrogen peroxide to CPP-ACP might vary from 1:6 to 3:4, it depends upon the reaction of opacity to the bleaching agent. [24]

11. Resin infiltration

As previously noted, RI may offer some advantages in the aesthetic treatment of MIH incisors. Since the refractive indexof the resin infiltrant is (1.52) close to that of healthy enamel (1.62), the optical properties can be effectively improved by increasing the translucency and improving the aesthetics. [25]

In 2013, Attal et al. described a "deep resin infiltration technique" that uses an intraoral sandblasting device to prepare the affected tooth and allow the infiltration to reach the entire extent of the lesion. This should prevent surface enamel larger than 500 μm from being removed. Also, some composites may be applied to the tooth surface after the resin has penetrated. The bond between the resin penetrant and the composite is excellent. Studies assessing the durability of aesthetic improvements have shown consistent effects for at least 6 months, but the main drawback is the discoloration of the material. [5,25]

Paris et al. in 2013 also conducted an in-vitro study discussing masking the white spots of MIH by RI and found that infiltrating enamel that's well polished is resistant to discoloration. However, this information is connected to the conventional resin infiltration technique, as the resin infiltrant kept away from touch with the external environment in the case of deep penetration. Generally, the application of the resin infiltration approach in MIH teeth needs more research, improvements in qualities of material, and/or procedure adjustments before it can be highly advocated in MIH situations. [26]

12. Composite restorations or veneers

Composite resin restorations remove defective enamel and build composite resins with opaque resins to prevent excessive loss of enamel. [11,13] Composite veneers, on the other hand, are a more conservative method because they can be performed without tooth preparation, that is, without even removing the enamel of defective teeth. These treatments may be recommended for larger enamel defects caused by exposed dentin or broken enamel. [11] Etching with 5% sodium hypochlorite and then

pre-treating for 1 minute significantly improves the adhesive strength of the low-mineralized enamel. Long-term maintenance of restorations is essential because composite resins are prone to discoloration, detoriration, and loss of integrity of margins.

13. Porcelain veneers

This treatment line is recommended for patients above the age of 18 who developed matured gingival margin. This technique could be an alternative when other options have failed to give satisfactory results. [11,23]

14. Conclusions:

In conclusion, primitive diagnosis of children with MIH can monitor PFMs and incisor and take precautions if the affected area is accessible. Aesthetic treatment of MIH incisors should be conservative as much as possible allowing for preventative measures to be implemented as soon as the afflicted areas are accessible. The Aesthetic treatment of MIH incisors should be as conservative as possible. In mild to moderate MIH cases, remineralization and resin infiltration are possibly efficient preserving methods, although these treatment options require additional investigation to establish the optimum technique/protocol in employing them. Surfaces with less RC involvement after removing all discolored low-mineralized enamel, placing the margins of the cavities in apparently normal enamel, pretreating with sodium hypochlorite and bleaching with self-etching primer adhesive is recommended to repair. Extracoronal restorations or extraction may be required for severely affected molars. Further research is needed to clarify proper guidelines to be followed in order to manage MIH cases and enhance the restorations' durability of affected teeth.

Abbreviations:

- MIH: molar incisor hypomineralization;
- PFMs: permanent first molars;
- PEB: post-eruptive enamel breakdown;
- EAPD: European Academy of Pediatric Dentistry;
- MIH-SSS: molar incisor hypomineralization- Severity Scoring System;
- MIH-TNI: molar incisor hypomineralization- Treatment Need Index;
- CPP-ACP: casein phosphopepetide amorphous calcium phosphate;
- RI: resin infiltration;
- GIC: glass ionomer cements;
- RMGIC: resin-modified glass ionomer cements;
- PMRC: polyacid modified resin composites;
- RC: resin composites;
- SSCs: stainless steel crowns;
- SPMs: second permanent molars.

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