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Review
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Minimum intervention dentistry in the management of early childhood caries lesions: A narrative review

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Highlights

- Early childhood caries management requires minimally invasive strategies tailored to lesion type, promoting age-appropriate and tissue-preserving care.
- Minimum intervention dentistry strategies, from non-invasive to mixed approaches, offer evidence-based options balancing efficacy, comfort, and practicality.
- Clinical decisions should follow lesion characteristics and current expert consensus to ensure rational and personalized treatment planning for early childhood caries.

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Abstract

Early childhood caries (ECC) is defined as the presence of one or more cavitated or noncavitated lesions, missing (due to caries), or filled surfaces in any primary tooth in a child under six years of age. ECC is a prevalent and chronic condition that requires effective, evidence-based management. This narrative review aimed to present an evidence-based overview of minimally invasive dentistry (MID) strategies for the management of ECC, focusing on their clinical rationale, classification, and application based on lesion characteristics. A comprehensive literature search was conducted using PubMed, Scopus, and Web of Science to identify recent studies, systematic reviews, and clinical guidelines published between 2019 and 2025. MID strategies were categorized as non-invasive, micro-invasive, minimally invasive, and mixed, based on lesion activity, cavitation, and cleanability. Evidence from randomized controlled trials and meta-analyses supports the use of micro-invasive methods like sealants and resin infiltration for non-cavitated lesions, while minimally invasive and mixed strategies, including the Hall technique and selective caries removal, are more appropriate for cavitated lesions. Ultimately, ECC management should aim to retain teeth symptom-free until natural exfoliation while preserving function, form, and aesthetics with minimal tissue loss. The application of MID principles enables personalized, child-friendly treatment planning and should be guided by updated expert consensus and lesion-specific criteria.

Keywords: Caries Lesions; Consensus; Primary Tooth; Strategies

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INTRODUCTION

Early childhood caries (ECC) is defined by the American Academy of Pediatric Dentistry (AAPD)[1] as the presence of one or more cavitated or noncavitated caries lesions, missing teeth due to caries, or filled surfaces of any primary tooth in a child under the age of six. The definition of severe early childhood caries (S-ECC)[1] is 1) any sign of smooth-surface caries in a child younger than three years of age, 2) from ages three through five, one or more cavitated, missing (due to caries), or filled smooth surfaces in primary maxillary anterior teeth, or 3) a decayed, missing, or filled score of greater than or equal to four (age three), greater than or equal to five (age four), or greater than or equal to six (age five).

It is of the utmost significance to manage ECC, a significant chronic childhood disease. The current understanding of caries disease does not align with the traditional caries treatment approaches adopted for ECC management-which are insufficient to address a wide range of caries lesions, including extensive cavitations and initial phases.[2] Therefore, a minimum intervention dentistry (MID) approach aiming to restore function, form, and aesthetics with minimal loss of material should be adopted in ECC management.[3] MID enables managing ECC lesions effectively, as in all caries lesion management, by preventing unnecessary tissue loss and determining the correct treatment methods based on the principle that early diagnosis and treatment of caries is of utmost importance.[4]

MID strategies have been classified in the Delphi consensus[5,6] reports focusing on *'when to intervene in the caries process and on existing carious lesions'* as non-invasive, micro-invasive, minimally invasive, and mixed approaches. Although this classification was not originally developed ECC, in this narrative review, the management of ECC lesions is interpreted within the framework of this classification.

This narrative review aimed to provide a structured overview of ECC management strategies in line with the principles of MID, focusing on micro-invasive, minimally invasive, and mixed approaches. The goal is to highlight minimally invasive techniques that follow current caries management consensus statements and are better tolerated by children, thereby shifting traditional and more invasive treatments away from being mainstream options.

METHODS

In this review, the SANRA[7] criteria were followed, and the literature search was structured in accordance with SANRA Item 3 *'Description of the literature search'*. In this context, the aim was to identify up-to-date publications addressing MID approaches to the management of ECC. Electronic databases including PubMed/MEDLINE, Scopus, and Web of Science were searched using the following keywords and MeSH terms: *'early childhood caries'*, *'minimal intervention dentistry'*, *'nonrestorative cavity control'*, *'pit and fissure sealants'*, *'resin infiltration'*, *'proximal lesion'*, *'Hall technique'*, *'preventive dentistry'*, *'clinical decision-making'*, *'operative dentistry'*, *'conservative treatment'*, *'consensus'*, *'dental caries'*, *'tooth, deciduous'* and *'child, preschool'*.

The search focused on English-language publications published between 2019 and 2025. Eligible literature included systematic and meta-analysis, clinical study, consensus statements, and clinical guidelines related to MID-based management of ECC lesions. It has been addressed in accordance with the principles of the minimum intervention approach and the included clinical studies were summarized in Table 1, Table 2, Table 3 and Table 4 to enhance clarity.

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Table 1. Summary of studies on the use of sealants in the management of primary teeth

Authors, Year	Study Findings
Lam et al., 2021[12]	In this randomized controlled trial involving 3–4-year-old children, the efficacy of 5% sodium fluoride varnish (NaFV) applied every 3 months was compared to a single application of glass ionomer sealants (GIS) in preventing or arresting occlusal caries in primary second molars. At baseline, 323 children (1,159 molars) were included; 280 children (989 molars) were evaluated at 12 months. Caries progression into dentin occurred in 7.8% of molars in the NaFV group and 8.0% in the GIS group.
Santos et al., 2022[14]	This two-arm, tooth-randomized non-inferiority clinical trial compared the survival rates of sealing versus restoring cavitated dentine occlusal lesions (ICDAS 5) in primary molars using resin-modified glass ionomer cement (RMGIC). Sixty-eight molars were allocated to either sealing without caries removal or restoration after selective removal. Both sealing and restoration effectively arrested caries progression for two years.
Ruff et al., 2024[13]	In the CariedAway pragmatic noninferiority cluster-randomized clinical trial conducted between 2018 and 2023, 4100 children aged 5–13 from high-risk low-income minority populations in New York were followed. The study compared the effectiveness of silver diamine fluoride (SDF) and therapeutic sealants with ART in arresting and preventing dental caries. The crude incidence of dental caries in children treated with SDF was 10.2 per 1000 tooth-years vs 9.8 per 1000 tooth-years in children treated with sealants and ART (rate ratio, 1.05; 95% CI, 0.97-1.12).
Lam et al., 2020[16]	This systematic review and meta-analyses evaluated the effectiveness of different pit and fissure sealants in the prevention and arrest of occlusal caries in primary molars of children. Although odds ratios and retention rates were analyzed, the review concluded that there is currently insufficient well-controlled evidence to support the effectiveness of sealants in managing occlusal caries in primary molars.
Chen et al., 2021[8]	This systematic review and meta-analysis evaluated the effectiveness of caries infiltration and sealing in arresting lesion progression, with subgroup analyses based on dentition type and caries risk levels. Both infiltration and sealing significantly reduced lesion progression compared to non-invasive or placebo treatments (infiltration vs. non-invasive: OR = 0.21, 95% CI: 0.15–0.30; sealing vs. placebo: OR = 0.27, 95% CI: 0.18–0.42). In the primary dentition, both infiltration and sealing were significantly more effective than non-invasive treatments (OR = 0.30, 95% CI: 0.20–0.45),
Ramamurthy, 2022[15]	This Cochrane systematic review evaluated the effects of pit and fissure sealants compared to no sealant or other types of sealants in preventing caries on the occlusal surfaces of primary molars in children. Although two reviewers independently conducted study selection, data extraction, and risk of bias assessment, the review found low-quality evidence. Therefore, it could not draw firm conclusions about the effectiveness of sealants in preventing dental caries in primary teeth. The authors emphasized the need for well-designed studies with longer follow-up periods.
Amend et al., 2022[17]	This umbrella review evaluated the clinical effectiveness of pit and fissure sealants compared to each other or to no treatment in primary and permanent teeth of children and adolescents with at least 12 months of follow-up. The review concluded that current evidence is insufficient to draw firm conclusions regarding the effectiveness of sealants for caries prevention in primary molars of children.
Tasleem et al., 2025[9]	This systematic review and meta-analysis compared the effectiveness of microinvasive techniques with noninvasive or invasive methods in halting radiographic progression of interproximal caries lesions. The overall odds ratio was 0.29 (95% CI: 0.19–0.38), favoring microinvasive techniques over noninvasive ones. Subgroup analyses by dentition type (primary or permanent), type of microinvasive intervention, and caries depth level consistently showed superior outcomes for microinvasive techniques across all categories.

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Table 2. Summary of studies on the use of resin infiltration in the management of primary teeth

Authors, Year	Study Findings
Jorge et al., 2019[26]	In this split-mouth randomized controlled clinical trial, the efficacy of resin infiltration in arresting non-cavitated proximal lesions in primary molars was evaluated after a two-year follow-up. Fifty children with at least two radiographically detected proximal lesions (located in enamel or outer dentin) were included. In the resin infiltration group, caries progression was observed in 24.1% of lesions, compared to 55.2% in the control group (flossing only), with a statistically significant difference ($p = 0.012$).
Sarti et al., 2020[27]	In this split-mouth randomized controlled clinical trial, the effectiveness of resin infiltration in controlling early proximal carious lesions in primary molars was evaluated after a two-year period. Twenty-eight children with radiographically confirmed lesions (ranging from outer enamel to the outer third of dentin) participated. After two years, caries progression was observed in 54.1% of lesions in the resin infiltration group, compared to 79.2% in the control group ($p = 0.03$). Logistic regression analysis indicated that resin infiltration reduced the risk of lesion progression by 82% (OR = 0.18, 95% CI: 0.29–0.31).
Baniebrahim et al., 2024[25]	In this split-mouth clinical study, the effectiveness of resin infiltrant and Tooth Mousse in arresting proximal enamel caries in primary molars was compared. A total of 64 proximal surfaces in 32 children with radiographically confirmed non-cavitated enamel lesions were treated, with each child receiving both interventions on contralateral quadrants. In the resin infiltrant group, no caries progression was observed after 12 months, and all 32 treated surfaces (100%) demonstrated complete caries arrest.
Tedesco et al., 2021 [57]	In this systematic review and network meta-analysis, the effectiveness of different treatment strategies in preventing the progression of initial caries lesions in primary teeth was evaluated, based on studies with at least 12 months of follow-up. Eleven studies were included, covering various tooth surfaces (proximal, occlusal, buccal/lingual) and interventions such as fluoride varnish, resin infiltration, sealants, CPP-ACP paste, ozone therapy, and toothbrushing/flossing. Resin infiltration showed the highest probability of avoiding lesion progression across all surface types in primary teeth.
Cebula, 2023[58]	In this systematic review and meta-analysis, the effectiveness of resin infiltration in arresting proximal carious lesions in primary and permanent teeth was evaluated, along with the certainty of the evidence. Caries progression risk was significantly reduced for infiltrated lesions in primary teeth under per-protocol (PP), intention-to-treat (ITT), and best-case (BC) scenarios. Trial Sequential Analysis (TSA) confirmed firm evidence for these scenarios.

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Table 3. Summary of studies on the use of hall technique in the management of primary teeth

Authors, Year	Study Findings
Midani et al., 2019[33]	In a retrospective analysis of primary molars treated with the Hall technique at a pediatric dentistry clinic between 2011 and 2017, the authors reported a high success and survival rate of 92.3% over a mean follow-up period of 22 months; they concluded that the Hall technique is an effective minimally invasive treatment option for asymptomatic primary molars.
Schwendicke et al., 2019[34]	In a 5-year randomized controlled trial conducted in Scotland, the authors showed that primary molars treated with the Hall technique had a higher survival rate (99% vs. 92%) and significantly lower total treatment costs compared to direct conventional restorations; additionally, the Hall technique group experienced less pain, fewer endodontic interventions, and fewer extractions.
Bhatia et al., 2019[59]	The authors investigated the clinical efficacy and acceptability of the Hall technique for managing Class I and Class II caries lesions in 84 children aged 6 to 10 years. They reported no clinical or radiographic failures after a 6-month follow-up, noted that the postoperative increase in occlusal vertical dimension returned to normal within 6 months, and found that the technique was highly accepted by the children.
Binladen et al., 2020[60]	In their retrospective study comparing the clinical and radiographic success rates of preformed metal crowns placed on primary molars using the conventional method and the Hall technique at 6, 12, 18, and 24 months, the authors reported that both methods showed high success rates, but the Hall technique demonstrated a statistically significantly higher success rate at the 24-month follow-up.
Araujo et al., 2020[61]	In a 36-month clinical study comparing the restoration success of the ART and the Hall technique in primary molars with occluso-proximal caries in children aged 5–10 years, the authors reported that the Hall technique achieved approximately three times greater success than ART and that both approaches were highly accepted by children and their parents.
Kaptan and Korkmaz, 2021[62]	In a clinical study comparing the Hall technique with conventional compomer restorations for the management of occluso-proximal caries in primary molars of children aged 4–8 years, the authors reported that the Hall technique exhibited higher clinical success and lower failure rates at the one-year follow-up. Moreover, both treatment groups showed reductions in plaque and gingival scores.
Undre et al., 2023[36]	In a study comparing conventional compomer restorations, the Hall technique, and nonrestorative cavity control for the management of occlusal or proximal caries lesions in primary molars of children aged 5 to 8 years, the authors reported no statistically significant differences in clinical or radiographic success among the three approaches. However, they stated that the Hall technique demonstrated greater clinical success than conventional restorations, while nonrestorative cavity control was better accepted by children.
Pascareli-Carlos et al., 2023[63]	In a multicenter randomized clinical trial, the authors reported that, at the 12-month follow-up, the Hall technique demonstrated a higher survival rate (87.8%) compared to resin composite restorations (75.7%) in the treatment of cavitated caries lesions involving multiple surface in primary molars.
Oz et al., 2023[64]	In a randomized controlled trial comparing the clinical and radiographic success of the Hall technique and ART restorations in the treatment of occlusal caries in children aged 5–6 years, the authors reported that both approaches were successful at the 18-month follow-up; however, the Hall technique resulted in more stable clinical outcomes and better periodontal compatibility.
Narbutaite et al., 2024[35]	In a two-year randomized controlled trial involving children aged 3 to 8 years, the authors compared the clinical success rates of the Hall technique, conventional restorations, and nonrestorative cavity control, alongside evaluations of children's pain perception, behavior, and the perspectives of children, parents, and dentists regarding the treatments. They reported that the Hall technique achieved the highest clinical success, all methods were well tolerated by the children, but the Hall technique was technically more demanding, while conventional restorations required longer treatment durations.

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Table 3. Summary of studies on the use of hall technique in the management of primary teeth (continued)

Chua et al., 2022[65]	The authors, in a systematic review comparing the use of preformed metal crowns placed with either the conventional method or the Hall technique, reported that both methods achieved success rates exceeding 85% at 12- and 24-month follow-ups. Nonetheless, they highlighted that the Hall technique should be given greater consideration in standard treatment protocols due to its reduced clinical time, cost-effectiveness, and higher level of parental acceptance.
Hu et al., 2022[66]	In their systematic review of clinical studies conducted between 2007 and 2021, the authors reported that the Hall technique exhibited clinical success rates comparable to those of conventional preformed metal crowns and approximately 80% higher success rates than direct restorations, particularly in the management of proximal and multisurface dentin carious lesions. Furthermore, the technique was well tolerated by children and broadly accepted by parents.
Garbim et al., 2025[67]	In a systematic review and meta-analysis of randomized controlled trials with a minimum follow-up of 12 months, the authors compared five different methods (Hall technique, NRCC, conventional restorations, SDF, and ART) for the treatment of occluso-proximal caries in primary molars. They reported that the Hall technique demonstrated the highest efficacy with a success rate of 80.8%, while no statistically significant differences were observed among the other methods. The overall quality of evidence ranged from very low to moderate due to a high risk of bias in the included studies.

Table 4. Summary of studies on the use of selective caries removal of primary teeth

Authors, Year	Study Findings
Elhennawy et al., 2020[68]	In a 24-month randomized controlled trial comparing selective and stepwise caries tissue removal in the treatment of deep dentin caries lesions in children aged 3–9 years, the authors reported that both techniques demonstrated similar clinical success. However, the stepwise approach was significantly more costly and is therefore recommended only for the management of very deep lesions.
Pereira et al., 2020[69]	In a multicenter study comparing selective and nonselective caries tissue removal followed by composite restorations in posterior primary teeth with moderate depth of active caries, the authors reported high survival rates for both pulp and restoration outcomes after 33 months, with no significant difference between the two approaches.
Goldsmith et al., 2021[70]	In a three-year double-blind, randomized controlled clinical trial conducted in Brazil, the authors compared composite restorations placed after selective and nonselective caries tissue removal in primary molars with deep dentin caries and reported a statistically significant difference in survival rates: 81% in the nonselective removal group and 57% in the selective removal group.
Hamouda and Deery, 2021[58]	In their systematic review and meta-analysis evaluating nonselective caries removal, selective caries removal, and stepwise caries removal techniques in the treatment of deep caries lesions in vital primary teeth, the authors found that both selective and stepwise caries removal significantly reduced the risk of pulp exposure compared to nonselective caries removal.
Vaghasiya et al., 2024[57]	In a randomized controlled clinical trial conducted on primary molars with deep carious lesions, the authors reported that selective caries removal—where infected dentin was removed and affected dentin was retained—demonstrated clinical and radiographic success rates comparable to those of nonselective caries removal at 4- and 6-month follow-ups.

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Noninvasive Strategies

Noninvasive strategies, which were initially developed to prevent caries lesion formation without any loss of tooth hard tissue, are now also used in the control and management of the activity of existing lesions.[6] These strategies include dietary, biofilm, and mineralization control.[5,6] Dietary control is associated with the consumption of cariogenic foods, biofilm control with oral hygiene habits, and mineralization control with the use of demineralizing agents.[6]

Micro-invasive Strategies

Micro-invasive strategies involve reshaping the tooth's surface characteristics during acidification and causing a few micrometers of hard tissue to be lost. These strategies include sealant application and resin infiltration.[6,8,9]

Sealants

Sealants have traditionally been applied to occlusal surfaces and the method involves placing the sealant to prevent the development of a caries lesion or arrest an existing lesion. Sealant application creates a physical barrier on the tooth surface to prevent the accumulation of biofilm in pits and fissures, thus preventing acid diffusion and mineral loss. However, this method helps with mechanical biofilm control by remodeling the surface.[10] According to the *AAPD's Policy on Minimally Invasive Dentistry*,[11] sealants may be effective in preventing caries and arresting their progression, provided that they are regularly monitored and reapplied when necessary. In the management of ECC, sealants can be used for active noncavitated and microcavitated occlusal lesions in primary molars, considering studies that have demonstrated their effectiveness in primary molars.[12-14] However, in the context of primary molars, systematic reviews have noted that the evidence base is limited by the small number of well-designed randomized controlled trials and a generally low certainty of evidence.[8,9,15-17]

Sealant materials do not demonstrate structural strength against occlusal forces. This is not a problem when there is a solid tooth structure to support the underlying material. In deeper D2 and D3 lesions, the underlying demineralized weakened dentin cannot support the material, and when a sealant is placed over these lesions, mechanical deterioration of the sealant material occurs as a result of a trampoline-type effect on the tooth with occlusal forces.[18] In a randomized controlled clinical trial by Santos et al.,[14] sealing of ICDAS 5 occlusal lesions in primary molars using resin-modified glass ionomer cement (RMGIC) achieved lower survival rates compared to restorations; however, both approaches were effective in arresting lesion progression over a two-year period. However, the evidence supporting the routine sealing of dentinal cavitated lesions remains limited. Therefore, in ECC management, the use of sealants in primary molars should be guided by caries management protocols and current recommendations, which support their use in noncavitated carious lesions.[5,6]

In addition, sealant applications on proximal lesions have also been investigated, and promising results have been obtained in this area. In systematic review and meta-analysis studies conducted by Chen et al.[8] and Tasleem et al.,[9] the effectiveness of sealant application on the proximal surfaces of primary teeth, as in permanent teeth, has been demonstrated. At this point, in the management of ECC, sealant applications on primary molars can be considered as a micro-invasive option.

Most evidence relating to the choice of sealant material suggests that resin-based sealants should be used as the first material for retention and resistance to abrasion, while glass ionomer cements (GICs) should be used when moisture control is a concern.[19,20] Both types of material need to be

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monitored-particularly GICs, which carries a higher risk of loss.[21]

Sealant applications using high-viscosity GICs are also equivalent to the atraumatic restorative treatment (ART) sealant approach, which was included in the definition of the ART approach in 2017.[22] To achieve success in this approach, it is necessary to apply a surface preparation agent before placing the sealant and to pay attention to the step of moisture protection for the first 24 hours after the sealant application.[22]

Infiltration

Resin infiltration technique stands out as an effective and conservative approach, aligned with the principles of MID, for controlling noncavitated carious lesions.[23] The method is based on the rapid penetration of light-polymerized low-density resin into enamel after removal of the surface layer with hydrochloric acid and ethanol drying.[23]

In noncavitated lesions, characterized by a porous lesion body covered by an intact surface layer, the lesion body forms a passageway for acid diffusion into dentin. In resin infiltration, the so-called infiltrate (a low-viscosity, light-polymerized resin) penetrates the porous lesion body. Hence, the progression of the caries lesion is arrested due to the blockage of the diffusion pathway in the interface lesion. At the same time, the resin covers the enamel crystals in the lesion body and prevents further dissolution of the crystals.[23,24]

Evaluation of the current evidence on resin infiltration for the management of proximal carious lesions in primary teeth indicates that clinical trials conducted by Baniebrahim et al.,[25] Jorge et al.[26] and Sarti et al.[27] have demonstrated its efficacy in controlling lesion progression in primary molars. Furthermore, systematic reviews and meta-analyses by Chen et al.,[8] Tasleem et al.,[9] Cebula et al.,[28] and Tedesco et al.[29] have provided robust evidence supporting the effectiveness of resin infiltration in the management of noncavitated proximal lesions in primary dentition. Notably, among various surface types, resin infiltration has been consistently identified as the most effective approach in preventing lesion progression.

Regarding resin infiltration and sealant applications, systematic reviews and meta-analyses conducted by Tedesco et al.[29] and Tasleem et al.[9] reported that resin infiltration was more effective than fissure sealants in the management of proximal carious lesions in primary teeth. Collectively, the available evidence indicates that resin infiltration may represent a leading micro-invasive approach for managing proximal lesions in the context of ECC.

Mixed Strategies

Methods that are not included in any of the non-invasive, micro-invasive, or minimally invasive groups but include some of their features are called mixed strategies.[5,6]

Hall Technique

The Hall technique, combining the biological management of caries lesions and the restorative advantages of preformed metal crowns, the method involves capping the primary molar with a ready-made preformed metal crown cemented with GIC without any caries cleansing, crown preparation, or local anesthesia.[30-32]

The basic principle of the use of the Hall technique for primary molars is the clinically definite diagnosis of the absence of irreversible pulpitis or pulp necrosis, the exclusion of the presence of periradicular pathology on radiography, and the definite visualization of the dentin layer on the pulp.[32]

Clinical studies have demonstrated that the Hall technique is an effective treatment option consistent with the principles of MID. Midani et al.,[33] in a retrospective study conducted in a

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pediatric dental clinic, found a success and survival rate of 92.3% at a mean follow-up of 22 months. Similarly, Schwendicke et al.,[34] in a 5-year randomized controlled trial in Scotland, demonstrated a significantly higher survival rate (99%) and lower treatment costs in the Hall technique group compared to conventional restorations (92%). Additionally, teeth treated with the Hall technique experienced less pain, fewer endodontic interventions, and fewer extractions. Beyond clinical success, the acceptance of the Hall technique by children, parents, and clinicians has also been highlighted in numerous studies. Narbutaite et al.[35] reported that the Hall technique was well tolerated by children and accepted by parents. Similarly, Undre et al.[36] found that the Hall technique was more acceptable to children compared to conventional restorations and nonrestorative cavity control (NRCC).

Studies have shown that the Hall technique can be utilized not only for carious lesions but also for the management of local or generalized developmental defects in teeth. BaniHani and Duggal[37] and Wright[38] reported that the Hall technique can be applied preventively in the management of defects such as enamel hypoplasia, dentinogenesis imperfecta, and amelogenesis imperfecta, regardless of lesion activity or the presence of cavitation. In light of these findings, it stands out as a potentially preferable strategy in the management of ECC, particularly for primary molars with active cavitated lesions.

Nonrestorative Cavity Control

Nonrestorative Cavity Control (NRCC) in ECC management can be applied in active cavitated caries lesions in primary teeth to keep the tooth in the mouth symptom-free until the exfoliation period. For this method to be applied, the tooth should not have symptoms/signs indicating that the pulp is affected.[39]

NRCC is an innovative three-stage treatment option that aims to halt the caries lesion instead of completely cleansing and restoring it. The first stage of the method involves improving the patient's oral hygiene habits. The other two stages are removal of the overhanging enamel harboring biofilm or, in the presence of a cavity on the proximal surface, enlargement of this surface to make it cleansable (second stage), followed by the application of 38% silver diamine fluoride or 5% sodium fluoride to prevent the risk of recurrence of lesion activity (third stage).[40] This management strategy allows repeated removal of the biofilm, preventing lesion progression and promoting tissue remineralization.[41] As this is a method that does not require anesthesia, it is a suitable option for uncooperative children who cannot accept other treatments, but the willingness and ability of the child and parent/carer to accept responsibility plays a key role in the success of the process rather than the clinician.[42]

It is important to acknowledge that the current evidence supporting the effectiveness of NRCC remains limited. In their umbrella review, BaniHani et al.[43] emphasized that the existing evidence base is insufficient and of low methodological quality; thus, robust conclusions regarding the clinical efficacy of this technique cannot yet be drawn.

Minimally Invasive Strategies

Minimally invasive strategies involve the selective removal of dental hard tissue, followed by long-lasting restorative techniques. Minimally invasive strategies for ECC management can be applied in active cavitated primary teeth where restorative interventions are unavoidable. These strategies aim to protect the pulp-dentin complex, halt caries lesion activity by sealing the cavity and interrupting its relationship with the oral environment, provide biofilm control, and restore tooth function, form, and aesthetics.[44] In the caries lesion removal step,

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instead of the traditional approach of removing the entire caries lesion, which is now called nonselective removal, the "selective removal of the caries lesion" approach proposed by the International Caries Consensus Collaboration[45] should be followed, and the treatment should be completed with minimally invasive restoration.

Selective Removal of Caries Lesions

Selective caries lesion removal refers to the removal of different amounts of caries in the peripheral and pulpal areas, depending on the depth of the lesion.[46,47] In this approach, caries tissue is selectively removed up to firm dentin on the pulpal surface and up to hard dentin in the peripheral area in shallow and moderate lesions.[48,49]

In the treatment of deep lesions, selective caries tissue is removed up to soft dentin to prevent pulp perforation. This process involves the removal of caries tissue up to hard dentin on the periphery of the lesion and up to soft dentin on the pulpal surface. Conservative caries tissue removal strategies that reduce the risk of tissue loss and pulp exposure in asymptomatic primary teeth with deep lesions need to be balanced with adequate tissue removal to maximize restoration life.[48,49]

Minimally invasive approaches based on the principle of selective caries removal can be considered an effective option in ECC management when appropriate case selection is made. In this context, ART can also be applied as a technique consistent with this principle. Especially in deep lesions extending into the inner third or quarter of dentin, it has the potential to reduce the risk of pulp exposure in asymptomatic, vital primary teeth.[37] However, in such cases, there should be no clinical signs or symptoms indicating pulpal involvement.[43] For minimally invasive restoration after selective removal of caries lesions, the AAPD guideline[50] "Evidence of Efficacy of Various Dental Materials/Techniques in Primary Teeth with Regard to Caries Lesion Classifications" should be followed.

Which Strategy, When?

In the management of ECC, the primary objective is to retain the teeth in the oral cavity without symptoms until their natural exfoliation, while preserving their form, function, and esthetic integrity.[5,6] Accordingly, when adopting the minimally invasive dentistry (MID) approach in ECC, its fundamental principles must be considered. The implementation of MID strategies should be guided by a stepwise assessment of lesion activity, cavitation, and cleansability.[5,6] Decision-making regarding the most appropriate management strategy should follow a rational and evidence-based framework, and MID applications in primary teeth should be evaluated in conjunction with the current body of evidence. The steps presented in the following sections are intended first to introduce the principles of the MID approach to the reader, and then to provide a structured framework for the management of ECC lesions in accordance with these principles.

General Principles

First, lesion activity should be assessed.[5,6] The general principles of the MID approach are presented below.

- Inactive lesions appear as scars, and regardless of cavitation, function, form, or aesthetic reasons, they do not require any treatment.[5,6]
- Active lesions need to be managed.[5,6]
- Active noncavitated caries lesions should be treated with non-invasive or micro-invasive strategies.[5,6]
- Cleansability should be assessed in the management of active cavitated caries lesions.[5,6]

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- Active cavitated and cleansable caries lesions should be treated with non-invasive, micro-invasive, or mixed strategies.[5,6]
- Active cavitated and noncleansable caries lesions should be treated with minimally invasive or mixed strategies.[5,6]

ECC can be addressed within the framework of the MID approach as follows: It appears appropriate to follow the principles of the MID approach as they are, particularly in the management of inactive lesions and active noncavitated caries lesions. However, considering the limited level of evidence available for primary teeth, the use of minimally invasive and mixed strategies seems to be a more appropriate option in the management of active cavitated lesions (Figure 1).

Occlusal Enamel Lesions

The principles of the MID approach regarding occlusal enamel lesions are presented below.

- Radiographically active lesions limited to enamel are assumed to be noncavitated. Occlusal enamel lesions without cavitation should be treated with non-invasive or micro-invasive strategies.[5,6]
- The probability of cavitation in enamel lesions is extremely low. Active cavitated occlusal enamel lesions (rarely) should be treated with micro-invasive or mixed strategies.[5,6]

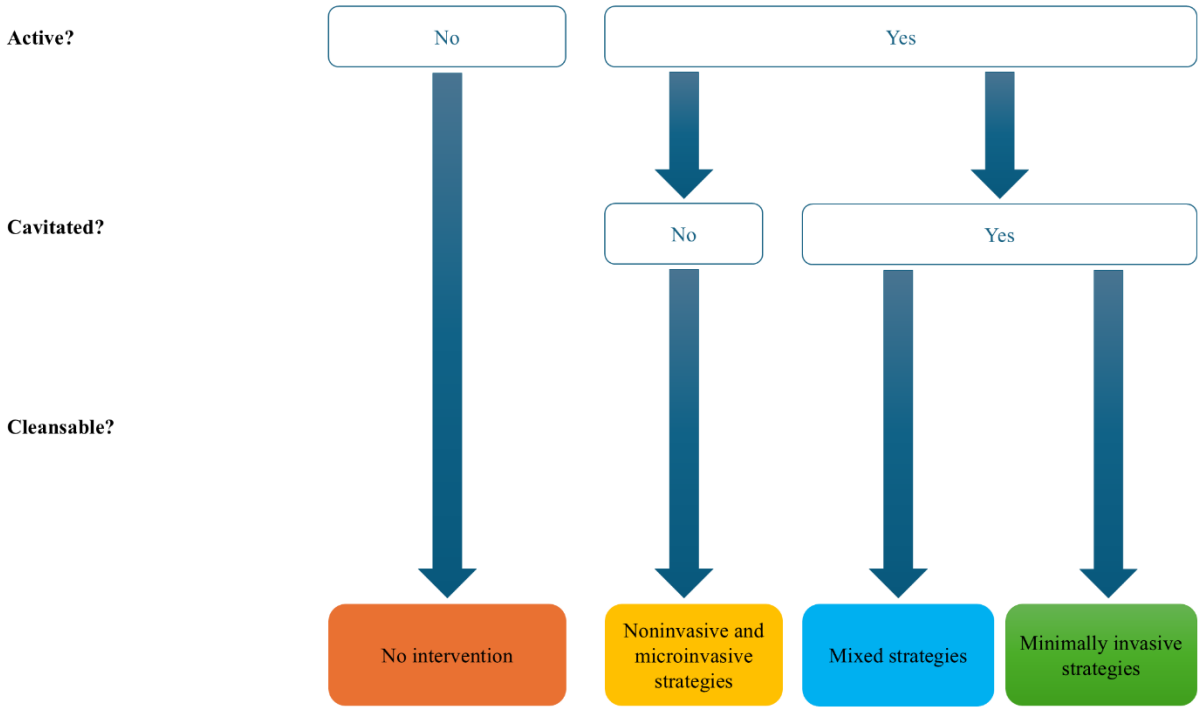

Figure 1. General principles of minimally invasive dentistry (MID) management strategies for early childhood caries (ECC) lesions[5,6]

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ECC can be addressed within the framework of the MID approach as follows: In the context of primary teeth, sealant applications, which are one of the micro-invasive strategies used in the management of occlusal enamel lesions, represent an approach for which the level of evidence currently insufficient, particularly in the presence of cavitation (Figure 2).

Occlusal Dentin Lesions

The principles of the MID approach regarding occlusal dentin lesions are presented below.

- A subgroup of cavitated lesions is microcavitated lesions, which include small cavitations in enamel and lesions in dentin without clear cavitation, as well as lesions with an International Caries Detection and Assessment System score of 3-4.[5,6,51-56]
- Radiographically active D1 lesions extending to the outer third of dentin may be with or without cavitation. However, these lesions are considered much more likely to be noncavitated. Active and noncavitated D1 lesions should be treated with micro-invasive strategies, while D1 lesions with clear cavitation should be treated with minimally invasive or mixed strategies.[5,6]
- In the treatment of active and microcavitated lesions (International Caries Detection and Assessment System score of 4), a micro-invasive strategy of sealant application may be preferred, but this method presents lower success rates.[5,6,53-56]
- Radiographically active D2-D3 lesions extending into the middle and inner third of dentin should be treated with minimally invasive or mixed strategies, with or without cavitation. These lesions are usually contaminated, demineralized, and cavitated. In their management, non-invasive strategies are inadequate, and micro-invasive strategies are limited by the stability of the restoration material.[5,6]

ECC can be addressed within the framework of the MID approach as follows: Based on the current evidence discussed in this narrative review on primary teeth, there is insufficient evidence to support the appropriateness of micro-invasive treatment options within the MID approach for lesions extending into the dentin. For now, minimally invasive or mixed strategies such as the Hall technique appear to be more appropriate for managing occlusal dentin lesions in primary teeth (Figure 2).

Proximal Enamel Lesions

The principles of the MID approach regarding proximal enamel lesions are presented below.

- Although radiographically active lesions limited to enamel are assumed to be noncavitated, these lesions should be treated with non-invasive or micro-invasive strategies.[5,6]
- Although the likelihood of cavitation in enamel lesions is extremely low, these lesions should be treated with minimally invasive or mixed strategies when clinically clear cavitation is detected.[5,6]

ECC can be addressed within the framework of the MID approach as follows: Based on the current evidence, following the principles of the MID approach appears appropriate in the management of proximal enamel lesions (Figure 3).

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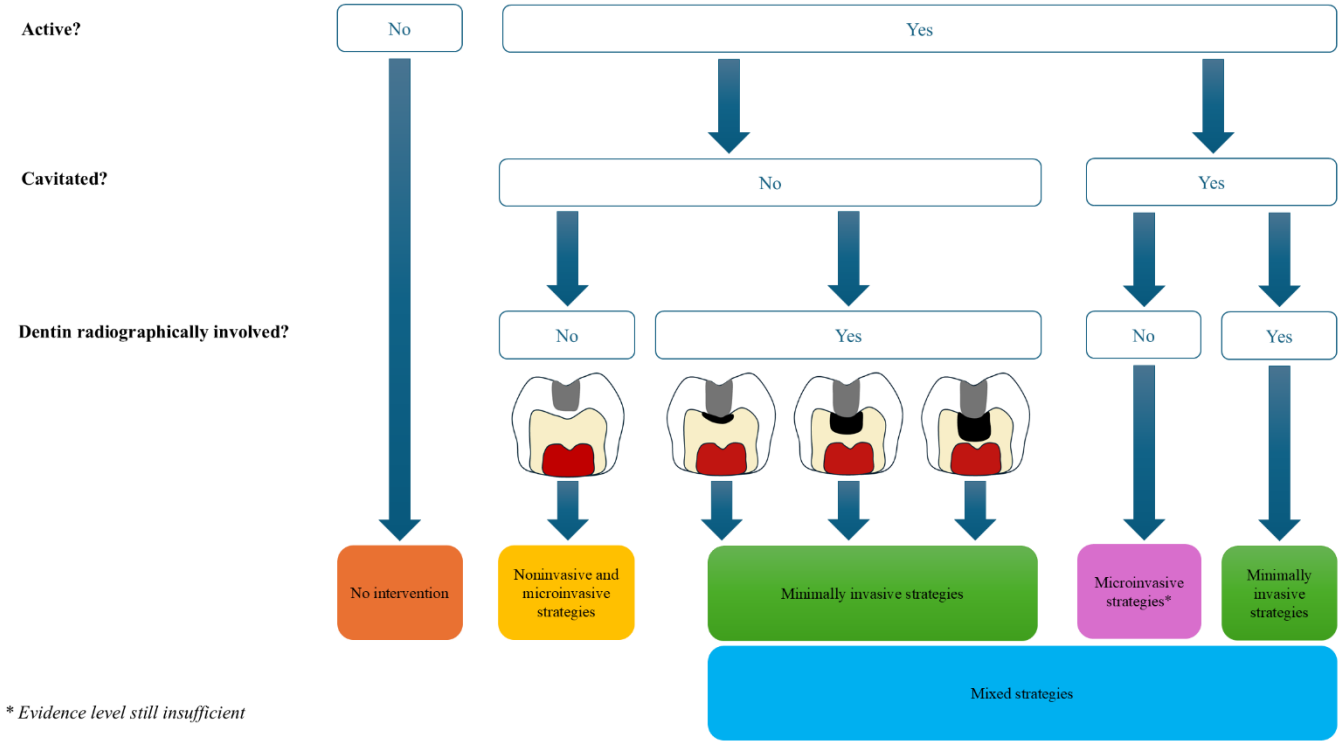

Figure 2. Minimally invasive dentistry (MID) management strategies for occlusal enamel and dentin lesions in early childhood caries (ECC)[5,6]

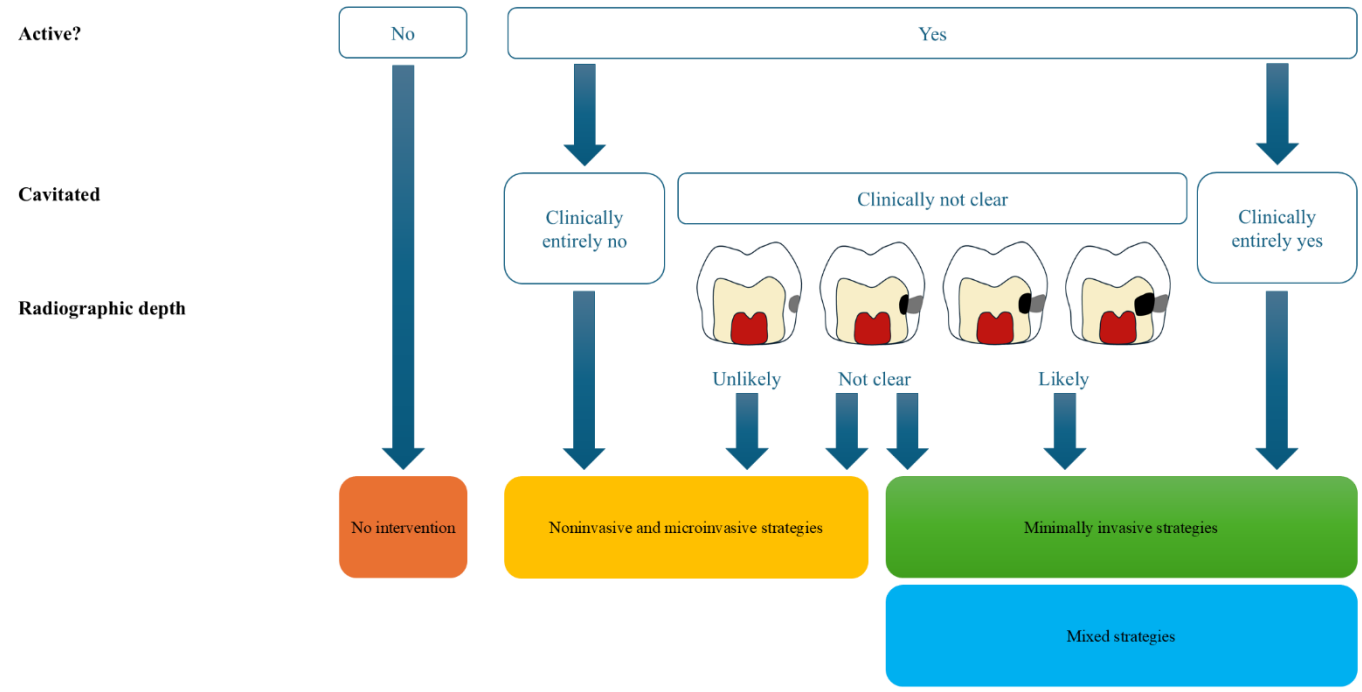

Figure 3. Minimally invasive dentistry (MID) management strategies for proximal enamel and dentin lesions in early childhood caries (ECC)[5,6]

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Proximal Dentin Lesions

The principles of the MID approach regarding proximal dentin lesions are presented below.

- Although the detection of cavitation in proximal lesions is difficult under clinical conditions, these lesions should be treated with mixed or invasive strategies in the presence of clear cavitation.[5,6]
- Radiographically active D1 lesions extending into the outer third of dentin should generally be considered noncavitated and treated with non-invasive or micro-invasive strategies.[5,6]
- Radiographically active D2-D3 lesions extending into the middle and inner third of dentin should be considered cavitated and treated with invasive or mixed strategies.[5,6]

ECC can be addressed within the framework of the MID approach as follows: Based on the current evidence, micro-invasive strategies appear appropriate for the management of non-cavitated lesions, whereas minimally invasive or mixed strategies seem more suitable for the management of cavitated lesions (Figure 3).

CONCLUSIONS

MID provides a preventive and effective method for managing ECC lesions, with an emphasis on the preservation of tooth tissue. By prioritizing the form, function, and aesthetic features of the teeth and ensuring that they remain in the mouth without symptoms until the exfoliation period, MID enhances the oral health of children. Nonetheless, this method's minimum invasiveness helps young patients feel less anxious about their treatments, which makes it an effective tool for parents and dentists to address ECC. Expert consensus recommendations should serve as a guide for the rational and justifiable decision-making process for selecting a plan for minimally invasive dental care of ECC lesions.

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