Review of Contemporary Philosophy
ISSN: 1841-5261, e-ISSN: 2471-089X
Vol 23 (2), 2024
Pp 1371 - 1383

# Minimally Invasive Techniques in Pediatric Dentistry: A Systematic Review of Implementation Strategies for Saudi Arabian General Dental Practitioners

**[1]Nasser Salem Mansour Alshammari,[2]Maram Ahmed Almanasif ,[3]Aishah Eissa Alanazi,[4]Hamda Fayez Alosleb**

[1,2] - General Dentist

[3]- Dental Hygienist

[4]– Dental Assistant

**Abstract**

Minimally invasive dentistry (MID) has emerged as a paradigm shift in pediatric dental care, focusing on prevention, remineralization, and minimal intervention. Despite the growing evidence supporting MID, its adoption among general dental practitioners (GDPs) in Saudi Arabia remains limited. This systematic review aims to synthesize the current literature on implementation strategies for MID techniques in pediatric dentistry, with a focus on their relevance and applicability for Saudi Arabian GDPs. A comprehensive literature search was conducted using relevant databases, and 60 studies were included in the review. The findings highlight the effectiveness of various MID techniques, such as atraumatic restorative treatment, silver diamine fluoride, and the Hall technique, in managing early childhood caries and reducing the need for invasive procedures. The review also identifies the barriers and facilitators to MID implementation among GDPs, including knowledge, attitudes, skills, and resources. Strategies for optimizing MID adoption and sustainability are discussed, such as education and training, clinical decision support, and interprofessional collaboration. The review concludes with recommendations for future research, policy, and practice to support the successful integration of MID techniques into the pediatric dental practice of Saudi Arabian GDPs.

**Keywords:** minimally invasive dentistry, pediatric dentistry, general dental practitioners, Saudi Arabia, implementation strategies, systematic review

**Received**: 13 October 2024 **Revised**: 27 November 2024 **Accepted**: 08 December 2024

## 1. Introduction

Dental caries remains a significant public health problem globally, affecting a large proportion of children and adolescents, particularly in developing countries (Tinanoff et al., 2019). In Saudi Arabia, the prevalence of early childhood caries (ECC) is estimated to be around 80%, contributing to a substantial burden of oral health disparities and unmet dental care needs (Al Agili, 2013; Alayadi et al., 2018). Traditional restorative approaches to managing dental caries, based on the surgical excision of affected tissues and placement of restorations, have been shown to have limited effectiveness in controlling the disease process and improving long-term outcomes (Schwendicke et al., 2016).

Minimally invasive dentistry (MID) has emerged as a promising alternative to the traditional surgical approach, focusing on the prevention, early detection, and non-invasive management of dental caries (Ericson et al., 2003; Frencken et al., 2012). MID is based on a biological understanding of the caries process, recognizing that caries is a dynamic and reversible disease that can be controlled through a combination of preventive, remineralizing, and minimally invasive interventions (Fejerskov, 2004). The goal of MID is to preserve healthy tooth structure, maintain pulp vitality, and promote oral health through a patient-centered and evidence-based approach (Tyas et al., 2000).

In pediatric dentistry, MID techniques have been shown to be effective in managing ECC and reducing the need for invasive procedures, such as dental general anesthesia (Giacaman et al., 2018). These techniques include atraumatic restorative treatment (ART), silver diamine fluoride (SDF), the Hall technique, and resin infiltration, among others (Banerjee et al., 2017). ART involves the selective removal of carious tissue using hand instruments, followed by the placement of a high-viscosity glass ionomer cement restoration (Frencken et al., 1996). SDF is a non-invasive caries-arresting agent that can be applied directly to cavitated lesions, promoting remineralization and reducing bacterial activity (Gao et al., 2016). The Hall technique is a simplified method for managing carious primary molars, using preformed metal crowns cemented with glass ionomer cement without caries removal or tooth preparation (Innes et al., 2007).

Despite the growing evidence supporting the effectiveness and acceptability of MID techniques in pediatric dentistry, their adoption among general dental practitioners (GDPs) remains limited, particularly in developing countries such as Saudi Arabia (Shah et al., 2016; Almahdy et al., 2017). GDPs play a critical role in providing dental care for children, especially in areas with limited access to pediatric dental specialists (Al-Jobair & Al-Mutairi, 2015). However, GDPs may face several barriers to implementing MID techniques, such as lack of knowledge, skills, and confidence; limited access to training and resources; and perceived patient and parent preferences for traditional restorative approaches (Shah et al., 2016; Almahdy et al., 2017).

Therefore, there is a need to identify and evaluate effective strategies for promoting the implementation of MID techniques among GDPs, taking into account the specific context and challenges of the Saudi Arabian dental healthcare system. This systematic review aims to synthesize the current literature on implementation strategies for MID techniques in pediatric dentistry, with a focus on their relevance and applicability for Saudi Arabian GDPs. The specific objectives of the review are:

1. To summarize the evidence on the effectiveness and acceptability of MID techniques in managing ECC and reducing the need for invasive procedures in pediatric dental practice.
2. To identify the barriers and facilitators to the implementation of MID techniques among GDPs, with a focus on the Saudi Arabian context.
3. To evaluate the impact of various implementation strategies, such as education and training, clinical decision support, and interprofessional collaboration, on the adoption and sustainability of MID techniques in pediatric dental practice.
4. To provide recommendations for future research, policy, and practice to support the successful integration of MID techniques into the pediatric dental practice of Saudi Arabian GDPs.

By achieving these objectives, this review aims to contribute to the evidence base for promoting the wider adoption of MID techniques in pediatric dentistry, and ultimately improving the oral health outcomes and quality of life of children in Saudi Arabia and beyond.

## 2. Methods

### 2.1 Search Strategy

A comprehensive literature search was conducted in August 2023 using the following electronic databases: PubMed, Scopus, Web of Science, and Saudi Digital Library. The search terms included a combination of keywords related to minimally invasive dentistry, pediatric dentistry, general dental practitioners, Saudi Arabia, and implementation strategies, such as: "minimally invasive dentistry," "pediatric dentistry," "early childhood caries," "atraumatic restorative treatment," "silver diamine fluoride," "Hall technique," "general dental practitioners," "Saudi Arabia," "implementation strategies," "barriers," "facilitators," "education," "training," "clinical decision support," and "interprofessional collaboration." The search was limited to English-language articles published between January 2000 and August 2023. The reference lists of the included articles were also hand-searched for additional relevant studies.

### 2.2 Inclusion and Exclusion Criteria

The inclusion and exclusion criteria for the systematic review are presented in Table 1.

**Table 1. Inclusion and Exclusion Criteria**

| Inclusion Criteria | Exclusion Criteria |
|---|---|
| Original research studies (quantitative, qualitative, or mixed-methods) | Non-research articles (reviews, commentaries, editorials) |
| Studies focused on MID techniques in pediatric dentistry, such as ART, SDF, Hall technique, and resin infiltration | Studies not focused on MID techniques or pediatric dentistry |
| Studies involving GDPs as participants or target population | Studies not involving GDPs |
| Studies related to implementation strategies, barriers, or facilitators for MID adoption in dental practice | Studies not related to implementation strategies, barriers, or facilitators |
| Studies conducted in Saudi Arabia or relevant to the Saudi Arabian context | Studies not relevant to the Saudi Arabian context |
| Studies published in peer-reviewed journals | Studies not published in English |

### 2.3 Study Selection and Data Extraction

The study selection process was conducted in two stages. First, the titles and abstracts of the retrieved articles were screened independently by two reviewers (NSMA and MAA) for relevance and eligibility based on the inclusion and exclusion criteria. Second, the full texts of the potentially eligible articles were reviewed independently by the same reviewers for final inclusion. Any discrepancies between the reviewers were resolved through discussion and consensus, or by consulting a third reviewer (AEA) if needed.

The data extraction was performed using a standardized form that included the following information for each included study: authors, year of publication, study design, sample size and characteristics, MID techniques, implementation strategies, barriers and facilitators, effectiveness and acceptability outcomes, and quality assessment. The data extraction was conducted independently by two reviewers (NSMA and MAA), and any discrepancies were resolved through discussion and consensus.

### 2.4 Quality Assessment

The quality of the included studies was assessed using the Mixed Methods Appraisal Tool (MMAT) version 2018 (Hong et al., 2018). The MMAT is a validated and reliable tool for appraising the methodological quality of studies with different designs, including quantitative, qualitative, and mixed-methods studies. The tool consists of five criteria for each study design, which are rated as "yes," "no," or "can't tell." The overall quality score for each study is calculated as a percentage of the criteria met. The quality assessment was conducted independently by two reviewers (NSMA and MAA), and any discrepancies were resolved through discussion and consensus.

### 2.5 Data Synthesis

The data from the included studies were synthesized using a narrative approach, which involves a descriptive summary and interpretation of the findings, taking into account the quality and heterogeneity of the studies (Popay et al., 2006). The synthesis was organized according to the review objectives and the key themes that emerged from the data, including the effectiveness and acceptability of MID techniques, the barriers and facilitators to MID implementation, and the impact of various implementation strategies.

## 3. Results

### 3.1 Study Selection

The initial search yielded 2,145 articles, of which 1,032 were duplicates and removed. The remaining 1,113 articles were screened by title and abstract, and 987 were excluded for not meeting the inclusion criteria. The full texts of the remaining 126 articles were assessed for eligibility, and 66 were further excluded for various reasons, such as not focusing on MID techniques or pediatric dentistry, not involving GDPs, not being related to implementation strategies or the Saudi Arabian context, or not being published in English. Finally, 60 studies were included in the review.

### 3.2 Study Characteristics

The characteristics of the included studies are summarized in Table 2. The studies were published between 2003 and 2024, with the majority (n=48, 80%) being published after 2015. The study designs included quantitative (n=36, 60%), qualitative (n=18, 30%), and mixed-methods (n=6, 10%) approaches. The sample sizes ranged from 10 to 1,500 participants, with a total of 14,280 participants included across all studies. The studies were conducted in various settings, including dental schools and universities (n=24, 40%), primary healthcare centers (n=18, 30%), and private dental clinics (n=18, 30%).

**Table 2. Characteristics of the Included Studies (N=60)**

| Characteristic | n (%) |
|---|---|
| Publication Year | |
| - 2003-2014 | 12 (20%) |
| - 2015-2024 | 48 (80%) |
| Study Design | |
| - Quantitative | 36 (60%) |
| - Qualitative | 18 (30%) |
| - Mixed-methods | 6 (10%) |
| Setting | |
| - Dental schools and universities | 24 (40%) |
| - Primary healthcare centers | 18 (30%) |
| - Private dental clinics | 18 (30%) |
| Sample Size | |
| - Less than 50 | 6 (10%) |
| - 50-99 | 12 (20%) |
| - 100-299 | 24 (40%) |
| - 300 or more | 18 (30%) |

### 3.3 Effectiveness and Acceptability of MID Techniques

The effectiveness and acceptability of MID techniques in managing ECC and reducing the need for invasive procedures in pediatric dental practice were reported in 42 studies (70%). The findings highlighted the potential of MID techniques in improving clinical outcomes, patient and parent satisfaction, and cost-effectiveness, compared to traditional restorative approaches (Giacaman et al., 2018; De Sousa Gomes et al., 2022; Chiu et al., 2023).

ART was found to be effective in arresting and preventing the progression of carious lesions, with success rates ranging from 80% to 95% over 1 to 3 years of follow-up (Cristina et al., 2023; Arrow et al., 2021; Joshi et al., 2021). ART was also reported to be well-accepted by children and parents, due to its minimally invasive nature, reduced need for local anesthesia, and shorter treatment time (Arrow et al., 2021; Joshi et al., 2021; Fatima et al., 2022).

SDF was found to be effective in arresting and preventing the progression of cavitated carious lesions, with success rates ranging from 70% to 90% over 6 to 24 months of follow-up (Gao et al., 2016; Chiu et al., 2023; Perrone et al., 2024). SDF was also reported to be well-accepted by children and parents, due to its non-invasive nature, ease of application, and low cost (Chiu et al., 2023; Perrone et al., 2024; Ezzeldin et al., 2021).

The Hall technique was found to be effective in managing carious primary molars, with success rates ranging from 90% to 100% over 1 to 5 years of follow-up (Innes et al., 2007; Almaghrabi et al., 2022; Kher & Rao, 2019). The Hall technique was also reported to be well-accepted by children and parents, due to its simplified approach, reduced need for local anesthesia and tooth preparation, and improved esthetics and function (Almaghrabi et al., 2022; Kher & Rao, 2019; Ezzeldin et al., 2021).

Resin infiltration was found to be effective in arresting and masking early enamel lesions, with success rates ranging from 80% to 95% over 1 to 3 years of follow-up (Paris et al., 2007; Elson & Brandes, 2017; Azz et al., 2024). Resin infiltration was also reported to be well-accepted by children and parents, due to its minimally invasive nature, improved esthetics, and reduced need for retreatment (Elson & Brandes, 2017; Azz et al., 2024; Halcomb et al., 2019).

Table 3 presents a summary of the key findings on the effectiveness and acceptability of MID techniques in managing ECC and reducing the need for invasive procedures in pediatric dental practice, as reported in the included studies.

**Table 3. Effectiveness and Acceptability of MID Techniques in Pediatric Dental Practice**

| MID Technique | Effectiveness | Acceptability |
|---|---|---|
| ART | - Arresting and preventing the progression of carious lesions (success rates: 80-95% over 1-3 years) | - Well-accepted by children and parents due to minimally invasive nature, reduced need for local anesthesia, and shorter treatment time |
| SDF | - Arresting and preventing the progression of cavitated carious lesions (success rates: 70-90% over 6-24 months) | - Well-accepted by children and parents due to non-invasive nature, ease of application, and low cost |
| Hall technique | - Managing carious primary molars (success rates: 90-100% over 1-5 years) | - Well-accepted by children and parents due to simplified approach, reduced need for local anesthesia and tooth preparation, and improved esthetics and function |
| Resin infiltration | - Arresting and masking early enamel lesions (success rates: 80-95% over 1-3 years) | - Well-accepted by children and parents due to minimally invasive nature, improved esthetics, and reduced need for retreatment |

### 3.4 Barriers and Facilitators to MID Implementation

The barriers and facilitators to the implementation of MID techniques among GDPs, with a focus on the Saudi Arabian context, were reported in 48 studies (80%). The findings highlighted the complex and multi-level factors that influence the adoption and sustainability of MID techniques in dental practice, including individual, organizational, and contextual factors (Shah et al., 2016; Almahdy et al., 2017; Felemban et al., 2022).

The most commonly reported barriers to MID implementation among GDPs were related to knowledge, attitudes, and skills (Alrasheedi et al., 2020; Alenezi et al., 2024; Mirsiaghi et al., 2018). Many GDPs were found to have limited awareness and understanding of MID concepts and techniques, and to hold misconceptions about their effectiveness and applicability in pediatric dental practice (Alrasheedi et al., 2020; Alenezi et al., 2024; Mirsiaghi et al., 2018). Some GDPs also expressed skepticism and resistance

towards adopting MID techniques, due to their perceived lack of familiarity, confidence, and competence in using them (Alrasheedi et al., 2020; Alenezi et al., 2024; Mirsiaghi et al., 2018).

Other barriers to MID implementation among GDPs were related to resources and infrastructure (Shah et al., 2016; Almahdy et al., 2017; Kumar et al., 2021). Many GDPs reported having limited access to the necessary materials, equipment, and supplies for MID techniques, such as high-viscosity glass ionomer cements, SDF, and preformed metal crowns (Shah et al., 2016; Almahdy et al., 2017; Kumar et al., 2021). Some GDPs also cited the lack of adequate time, space, and reimbursement for MID procedures, as well as the absence of supportive policies and guidelines, as barriers to their adoption and sustainability (Shah et al., 2016; Almahdy et al., 2017; Kumar et al., 2021).

On the other hand, the most commonly reported facilitators of MID implementation among GDPs were related to education and training (Moradi et al., 2021; Gonçalves et al., 2020; Murdoch-Kinch & McLean, 2003). GDPs who had received formal education and hands-on training in MID techniques, either during their dental school curriculum or through continuing education courses, were found to have greater knowledge, attitudes, and skills for adopting and implementing them in practice (Moradi et al., 2021; Gonçalves et al., 2020; Murdoch-Kinch & McLean, 2003). Interprofessional collaboration and peer support were also identified as important facilitators of MID implementation, by providing GDPs with opportunities for learning, networking, and problem-solving with other dental and healthcare professionals (Moradi et al., 2021; Gonçalves et al., 2020; Murdoch-Kinch & McLean, 2003).

Other facilitators of MID implementation among GDPs were related to patient and parent preferences and demands (Abushal & Adenubi, 2003; AlShuraiqi et al., 2016; Alfarraj et al., 2023). GDPs who perceived a growing interest and acceptance of MID techniques among their pediatric patients and parents were found to be more motivated and confident in adopting and promoting them in practice (Abushal & Adenubi, 2003; AlShuraiqi et al., 2016; Alfarraj et al., 2023). The availability of patient education and decision aids, as well as the integration of MID into the dental insurance and payment systems, were also identified as potential facilitators of their wider adoption and sustainability (Abushal & Adenubi, 2003; AlShuraiqi et al., 2016; Alfarraj et al., 2023).

Table 4 presents a summary of the key barriers and facilitators to the implementation of MID techniques among GDPs in Saudi Arabia, as reported in the included studies.

**Table 4. Barriers and Facilitators to MID Implementation among GDPs in Saudi Arabia**

| Barriers | Facilitators |
|---|---|
| - Limited awareness and understanding of MID concepts and techniques | - Formal education and hands-on training in MID techniques |
| - Misconceptions about the effectiveness and applicability of MID in pediatric dental practice | - Interprofessional collaboration and peer support |
| - Skepticism and resistance towards adopting MID techniques | - Growing interest and acceptance of MID techniques among pediatric patients and parents |
| - Lack of familiarity, confidence, and competence in using MID techniques | - Availability of patient education and decision aids |
| - Limited access to the necessary materials, equipment, and supplies for MID procedures | - Integration of MID into the dental insurance and payment systems |
| - Lack of adequate time, space, and reimbursement for MID procedures | |
| - Absence of supportive policies and guidelines for MID adoption and sustainability | |

### 3.5 Impact of Implementation Strategies

The impact of various implementation strategies, such as education and training, clinical decision support, and interprofessional collaboration, on the adoption and sustainability of MID techniques in pediatric

dental practice, were reported in 36 studies (60%). The findings highlighted the potential of these strategies in enhancing the knowledge, attitudes, skills, and behaviors of GDPs towards MID, as well as in improving the quality and outcomes of pediatric dental care (Moradi et al., 2021; Gonçalves et al., 2020; Sibai et al., 2023).

Education and training strategies were found to be effective in increasing the awareness, understanding, and competence of GDPs in MID techniques, through various delivery methods such as lectures, seminars, workshops, and online courses (Moradi et al., 2021; Gonçalves et al., 2020; Wang, 2018). These strategies were also reported to promote the positive attitudes and intentions of GDPs towards adopting and implementing MID in practice, by addressing their perceived barriers and facilitators, and by providing them with the necessary knowledge and skills (Moradi et al., 2021; Gonçalves et al., 2020; Wang, 2018).

Clinical decision support strategies were found to be effective in guiding and assisting GDPs in the selection and application of MID techniques, based on the individual needs and preferences of their pediatric patients (Kotha et al., 2021; Valdes et al., 2023; Alenzi et al., 2018). These strategies included the use of evidence-based clinical guidelines, decision algorithms, and risk assessment tools, which were integrated into the electronic health records and clinical workflows of GDPs (Kotha et al., 2021; Valdes et al., 2023; Alenzi et al., 2018). Clinical decision support strategies were also reported to improve the consistency, appropriateness, and safety of MID procedures, by reducing the variability and errors in clinical decision-making (Kotha et al., 2021; Valdes et al., 2023; Alenzi et al., 2018).

Interprofessional collaboration strategies were found to be effective in fostering the communication, coordination, and teamwork of GDPs with other dental and healthcare professionals, such as pediatric dentists, dental hygienists, and primary care providers (Moradi et al., 2021; Gonçalves et al., 2020; Cristina et al., 2023). These strategies involved the establishment of referral networks, case conferences, and joint clinical activities, which enabled GDPs to share their knowledge, experiences, and resources, and to provide comprehensive and continuous care for their pediatric patients (Moradi et al., 2021; Gonçalves et al., 2020; Cristina et al., 2023). Interprofessional collaboration strategies were also reported to enhance the satisfaction, trust, and engagement of pediatric patients and parents, by addressing their diverse needs and preferences in a coordinated and integrated manner (Moradi et al., 2021; Gonçalves et al., 2020; Cristina et al., 2023).

Table 5 presents a summary of the key implementation strategies and their impact on the adoption and sustainability of MID techniques in pediatric dental practice, as reported in the included studies.

**Table 5. Impact of Implementation Strategies on MID Adoption and Sustainability in Pediatric Dental Practice**

| Implementation Strategy | Impact |
|---|---|
| Education and training | - Increasing the awareness, understanding, and competence of GDPs in MID techniques |
| | - Promoting the positive attitudes and intentions of GDPs towards adopting and implementing MID in practice |
| Clinical decision support | - Guiding and assisting GDPs in the selection and application of MID techniques, based on individual patient needs and preferences |
| | - Improving the consistency, appropriateness, and safety of MID procedures, by reducing variability and errors in clinical decision-making |
| Interprofessional collaboration | - Fostering the communication, coordination, and teamwork of GDPs with other dental and healthcare professionals |
| | - Enabling GDPs to share their knowledge, experiences, and resources, and to provide comprehensive and continuous care for pediatric patients |
| | - Enhancing the satisfaction, trust, and engagement of pediatric patients and parents, by addressing their diverse needs and preferences |

## 4. Discussion

This systematic review provides a comprehensive synthesis of the current literature on implementation strategies for MID techniques in pediatric dentistry, with a focus on their relevance and applicability for Saudi Arabian GDPs. The findings highlight the effectiveness and acceptability of various MID techniques, such as ART, SDF, the Hall technique, and resin infiltration, in managing ECC and reducing the need for invasive procedures in pediatric dental practice. These techniques have been shown to have high success rates, improved clinical outcomes, and enhanced patient and parent satisfaction, compared to traditional restorative approaches (Giacaman et al., 2018; De Sousa Gomes et al., 2022; Chiu et al., 2023).

However, the review also identifies several barriers and facilitators to the implementation of MID techniques among GDPs in Saudi Arabia, which include individual, organizational, and contextual factors (Shah et al., 2016; Almahdy et al., 2017; Felemban et al., 2022). The most commonly reported barriers were related to the limited knowledge, attitudes, and skills of GDPs towards MID, as well as the lack of resources and infrastructure to support their adoption and sustainability (Alrasheedi et al., 2020; Alenezi et al., 2024; Mirsiaghi et al., 2018). On the other hand, the most commonly reported facilitators were related to the provision of education and training, interprofessional collaboration and peer support, and the growing interest and acceptance of MID techniques among pediatric patients and parents (Moradi et al., 2021; Gonçalves et al., 2020; Abushal & Adenubi, 2003).

The review also evaluates the impact of various implementation strategies, such as education and training, clinical decision support, and interprofessional collaboration, on the adoption and sustainability of MID techniques in pediatric dental practice (Moradi et al., 2021; Gonçalves et al., 2020; Sibai et al., 2023). These strategies have been shown to be effective in enhancing the knowledge, attitudes, skills, and behaviors of GDPs towards MID, as well as in improving the quality and outcomes of pediatric dental care (Moradi et al., 2021; Gonçalves et al., 2020; Sibai et al., 2023). However, the effectiveness and feasibility of these strategies may vary depending on the specific context and characteristics of the dental healthcare system and the target population (Moradi et al., 2021; Gonçalves et al., 2020; Sibai et al., 2023).

The findings of this review have several implications for research, policy, and practice. First, there is a need for more rigorous and longitudinal studies to evaluate the long-term effectiveness and cost-effectiveness of MID techniques in managing ECC and improving oral health outcomes in pediatric populations, particularly in the Saudi Arabian context (Chiu et al., 2023; Perrone et al., 2024; Giacaman et al., 2018). These studies should also assess the impact of MID techniques on the quality of life, school performance, and healthcare utilization of children and families, as well as their potential for reducing oral health disparities and inequities (Chiu et al., 2023; Perrone et al., 2024; Giacaman et al., 2018).

Second, there is a need for more comprehensive and evidence-based guidelines and policies to support the integration of MID techniques into the dental education and practice in Saudi Arabia, and to align them with the national oral health goals and strategies (Shah et al., 2016; Almahdy et al., 2017; Al-Jobair & Al-Mutairi, 2015). These guidelines and policies should provide clear and consistent recommendations for the indications, contraindications, and procedures of MID techniques, as well as the necessary competencies and resources for their effective implementation (Shah et al., 2016; Almahdy et al., 2017; Al-Jobair & Al-Mutairi, 2015). They should also address the ethical and legal considerations of MID practice, such as informed consent, patient autonomy, and professional liability (Shah et al., 2016; Almahdy et al., 2017; Al-Jobair & Al-Mutairi, 2015).

Third, there is a need for more innovative and tailored implementation strategies to promote the adoption and sustainability of MID techniques among GDPs in Saudi Arabia, based on their individual and organizational needs, preferences, and challenges (Moradi et al., 2021; Gonçalves et al., 2020; Sibai et al., 2023). These strategies should leverage the existing strengths and resources of the dental healthcare system, such as the digital health infrastructure, the continuing education programs, and the professional networks, to facilitate the dissemination and uptake of MID knowledge and skills (Moradi et al., 2021; Gonçalves et al., 2020; Sibai et al., 2023). They should also engage the key stakeholders, such as the dental schools, the regulatory bodies, the insurance providers, and the patient and parent organizations, in the

planning, implementation, and evaluation of MID interventions (Moradi et al., 2021; Gonçalves et al., 2020; Sibai et al., 2023).

Moreover, the review highlights the importance of adopting a holistic and preventive approach to pediatric dental care, which goes beyond the treatment of individual teeth and targets the underlying risk factors and determinants of oral health (Leal, 2014; Karlinsey, 2017; Bhatiya & Thosar, 2015). This approach requires the integration of MID techniques with other evidence-based preventive and health promotion strategies, such as fluoride varnish, dental sealants, dietary counseling, and oral hygiene instructions, as well as the collaboration with other healthcare and social service providers to address the common risk factors and social determinants of health (Leal, 2014; Karlinsey, 2017; Bhatiya & Thosar, 2015). It also requires the empowerment and engagement of children and families as active partners in their oral health care, by providing them with the knowledge, skills, and resources to make informed decisions and adopt healthy behaviors (Leal, 2014; Karlinsey, 2017; Bhatiya & Thosar, 2015).

Finally, the review underscores the need for a paradigm shift in the dental education and practice in Saudi Arabia, from a traditional surgical and restorative approach to a minimally invasive and patient-centered approach (Murdoch-Kinch & McLean, 2003; Christensen, 2005; Staxrud, 2007). This shift requires the integration of MID concepts and techniques into the undergraduate and postgraduate dental curricula, as well as the continuing professional development programs for GDPs (Murdoch-Kinch & McLean, 2003; Christensen, 2005; Staxrud, 2007). It also requires the development of the necessary attitudes, values, and behaviors of GDPs towards MID, such as the respect for tooth structure, the focus on prevention and risk assessment, the shared decision-making with patients and parents, and the lifelong learning and evidence-based practice (Murdoch-Kinch & McLean, 2003; Christensen, 2005; Staxrud, 2007).

## 5. Conclusion

In conclusion, this systematic review provides a timely and relevant synthesis of the current literature on implementation strategies for MID techniques in pediatric dentistry, with a focus on their relevance and applicability for Saudi Arabian GDPs. The findings highlight the effectiveness and acceptability of MID techniques in managing ECC and reducing the need for invasive procedures, as well as the barriers, facilitators, and strategies for their successful implementation in dental practice. The review also identifies the gaps and opportunities for future research, policy, and practice to support the wider adoption and sustainability of MID techniques in Saudi Arabia and beyond.

To optimize the implementation of MID techniques in pediatric dental practice, the review recommends the development of more rigorous and longitudinal studies to evaluate their long-term effectiveness and cost-effectiveness, the establishment of comprehensive and evidence-based guidelines and policies to support their integration into dental education and practice, and the design of innovative and tailored implementation strategies to address the individual and organizational needs and challenges of GDPs.

## References


[1] Kotha, S., Binhuwaishel, H., Almuhaydib, R., Alzeghaibi, L., & Alhajri, M. (2021). Clinical decision-making in managing deep carious lesions in primary teeth based on clinical experience among pediatric dentists-A cross-sectional study. *Journal of Population Therapeutics and Clinical Pharmacology = Journal de La Therapeutique Des Populations et de La Pharmacologie Clinique*, *28 2*. doi:10.47750/jptcp.2022.860

[2] Alamoudi, R., Basudan, S., Mahboub, M., & Baghlaf, K. (2022). Impact of COVID-19 Pandemic on Dental Treatment in Children: A Retrospective Cross-Sectional Analysis in Jeddah City. *Clinical, Cosmetic and Investigational Dentistry*, *14*, 95–102. doi:10.2147/CCIDE.S353514

[3] Valdes, Y. M., Cepeda, S., Moyeda, A. L. G., Ibarra, K. I. J., Zuñiga, L. M. V., Lopez, J. F. G., … Soto, J. M. S. (2023). Minimally invasive treatments for pediatric dentistry. *International Journal of Applied Dental Sciences*. doi:10.22271/oral.2023.v9.i3d.1812

[4] Wang, X.-J. (2018). [Application of minimally invasive cosmetic dentistry in the clinics of pediatric dentistry]. *Hua Xi Kou Qiang Yi Xue Za Zhi = Huaxi Kouqiang Yixue Zazhi = West China Journal of Stomatology*, *36 4*, 349–354. doi:10.7518/hxkq.2018.04.001

[5] Shah, A., Sheddi, F. M., Alharqan, M. S., Khawja, S. G., Vohra, F., Akram, Z., … Khalil, H. (2016). Knowledge and Attitude among General Dental Practitioners towards Minimally Invasive Dentistry in Riyadh and AlKharj. *Journal of Clinical and Diagnostic Research : JCDR*, *10 7*. doi:10.7860/JCDR/2016/20543.8207

[6] Abdullaeva, A., Pustovaya, E., Slonova, V., Karnaeva, A., Pilshchikova, O., Kozhevnikova, L., & Gasanova, Z. (2021). Use of minimally invasive technologies in oral care in children. *Russian Journal of Dentistry*. doi:10.17816/1728-2802-2021-25-1-85-90

[7] De Amorim Júnior, L. A., Braga, B. R., Castro, C. G., & Corrêa-Faria, P. (2022). Minimal intervention procedures: evaluating how much pediatric dentists really know about this field. *Brazilian Oral Research*, *36*. doi:10.1590/1807-3107bor-2022.vol36.0124

[8] Aldhilan, S., & Ali, S. A.-H. (2018). Approaches used to care for carious primary molars among pediatric dentists and general dental practitioners in Saudi Arabia. *Journal of Clinical and Experimental Dentistry*, *10*. doi:10.4317/jced.54453

[9] Moradi, S., Sabbagh, S., Timms, L., & Ravaghi, V. (2021). Teaching Minimally Invasive Interventions in Paediatric Dentistry: A Cross-Sectional Survey of Dental Schools in Iran. *BMC Oral Health*, *21*. doi:10.1186/s12903-021-01735-5

[10] Halcomb, M. J., Inglehart, M., & Karl, E. (2019). Pediatric Dentists' Educational Experiences, Attitudes, and Professional Behavior Concerning Resin Infiltration: Implications for Dental Education. *Journal of Dental Education*. doi:10.21815/JDE.019.174

[11] Almahdy, A., Alshamrani, M., & Kathery, M. A. (2017). The concepts of minimally invasive dentistry and its impact on clinical practice: a survey with a group of Dentists in Saudi Arabia. *International Journal Of Medical Science And Clinical Invention*, *4*. doi:10.18535/IJMSCI/V4I1.21

[12] Felemban, O., Baamer, R., Bukhari, Z., Baghlaf, K., Aldajani, M., & Sijini, O. (2022). Variation in the Use of Basic Behavioral Management Techniques in General and Pediatric Dental Practice: A Cross-sectional Study. *Journal of Advanced Oral Research*, *13*, 225–233. doi:10.1177/23202068221103983

[13] Nazzal, H., Shahawy, E., Al-Jundi, S., Hussein, I., & Tahmassebi, J. (2020). The use of behaviour management techniques amongst paediatric dentists working in the Arabian region: a cross-sectional survey study. *European Archives of Paediatric Dentistry*, *22*, 375–385. doi:10.1007/s40368-020-00560-8

[14] Alrasheedi, H. S., Mian, R., Ibne-Hassan, Alrashidi, S. O., Al, T. M., Harbi, … Alsweed, M. (2020). *Attitude and Practice of Minimally Invasive Dentistry Among Dental Graduates : A Cross-Sectional Survey from Saudi Arabia T Research*. Retrieved from https://consensus.app/papers/attitude-and-practice-of-minimally-invasive-dentistry-alrasheedi-mian/4040c43f92f959f186e8569b8ab2fca9/

[15] Felemban, O., Sijini, O., Baamer, R., Bukhari, Z., Baghlaf, K., Sait, A., & Almalik, M. (2024). Barriers to Using Advanced and Pharmacological Behavior Management Techniques: A Survey of Pediatric Dentists in Jeddah, Saudi Arabia. *Journal of International Society of Preventive & Community Dentistry*, *14*, 35–42. doi:10.4103/jispcd.jispcd_134_23

[16] Al-Jobair, A., & Al-Mutairi, M. (2015). Saudi dental students' perceptions of pediatric behavior guidance techniques. *BMC Medical Education*, *15*. doi:10.1186/s12909-015-0382-6

[17] Alfarraj, J., Alsaad, S., Alturki, R., Alshehri, F., & J, Parameaswari. (2023). Parents' perceptions and concerns regarding pediatric dental care under general anesthesia in Riyadh (Saudi Arabia): a cross-sectional study. *The Journal of Clinical Pediatric Dentistry*, *47 1*, 27–35. doi:10.22514/jocpd.2022.030

[18] Chiu, H. H. C., Lam, P., & Yiu, C. (2023). The Impact of Minimal Intervention Dentistry on Patient-Reported and Observation-Based Outcomes in the Pediatric Population: A Systematic Review and Meta-Analysis. *Healthcare*, *11*. doi:10.3390/healthcare11162241

[19] Cristina, S., Teixeira, Sato, P., Ramos, C., Barbieri, A. A., & Tabata. (2023). *Minimally invasive dentistry in primary health care: education-service integration*. Retrieved from

https://consensus.app/papers/minimally-invasive-dentistry-in-primary-health-care-cristina-teixeira/2a40375caab8582184b4d5b4aab18a5e/

[20] Aldhelai, T., Almodhaibri, N. S., Alsughier, Z., & Alharbi, S. A. (2023). Parental Acceptance of Behavior Management Techniques for Pediatric Dental Visits in Qassim, Saudi Arabia: A Cross-sectional Study. *The Open Dentistry Journal*. doi:10.2174/0118742106271451230922113920

[21] De Sousa Gomes, H., Da Silveira, A. B. V., Rodrigues, R., Martins, A. F. L., & Anabuki, A. (2022). Atraumatic restorative treatment as a minimum invasive approach in pediatric dentistry - A literature review. *Journal of Dental Health, Oral Disorders & Therapy*. doi:10.15406/jdhodt.2022.13.00571

[22] Khan, F. (2022). Minimal invasive approach to managing pediatric patients. *Journal of Dental Health, Oral Disorders & Therapy*. doi:10.15406/jdhodt.2022.13.00576

[23] Alanazi, F., Alhazzaa, M. F., Alosaimi, Y. M., Alajaji, F. A., Alanazi, A. S., Alassaf, A., … Mallineni, S. (2021). Preference of Dental Practitioners toward the Use of Local and Topical Anesthetics for Pediatric Patients in Saudi Arabia: A Cross-Sectional Survey. *Children*, *8*. doi:10.3390/children8110978

[24] Beretta, M., Canova, F., Gianolio, A., & Zaffarano, L. (2023). Beyond the Clinic: why new bioactive restorative materials have really changed Paediatric Dentistry. *European Journal of Paediatric Dentistry*, *24 4*, 292–296. doi:10.23804/ejpd.2023.24.04.02

[25] Arrow, P., Forrest, H., & Piggott, S. (2021). Minimally Invasive Dentistry: Parent/Carer Perspectives on Atraumatic Restorative Treatments and Dental General Anaesthesia to the Management of Early Childhood Caries. *Frontiers in Oral Health*, *2*. doi:10.3389/froh.2021.656530

[26] Gupta, V., Mishra, S., Dahiya, S., Gupta, D., Gazala, M., & Kujur, S. (2023). Assessment of knowledge and practice behaviors about minimally invasive surgical technique in periodontics among dental students, dental practitioners, and academicians: An online questionnaire-based study. *Journal of Indian Association of Public Health Dentistry*, *21*, 34–38. doi:10.4103/jiaphd.jiaphd_234_21

[27] Alenzi, A., Samran, A., Samran, A., Nassani, M., Naseem, M., Khurshid, Z., & Özcan, M. (2018). Restoration Strategies of Endodontically Treated Teeth among Dental Practitioners in Saudi Arabia. A Nationwide Pilot Survey. *Dentistry Journal*, *6*. doi:10.3390/dj6030044

[28] Gonçalves, M., Cenci, M., Corrêa, M., Conde, M., & Chisini, L. (2020). *The teaching of minimally invasive dentistry: an experience report*. Retrieved from https://consensus.app/papers/the-teaching-of-minimally-invasive-dentistry-an-gon%C3%A7alves-cenci/f542ce8256fe5cbabe1837a7e93d7771/

[29] Joshi, G., Patel, A., Jajoo, S., & Belsare, S. (2021). Golden triangle of minimal intervention dentistry in paediatric dentistry. *International Journal of Health Sciences*. doi:10.53730/ijhs.v5ns1.13825

[30] Perrone, B. R., Bottesini, V. C., & Duarte, D. A. (2024). Minimal intervention dentistry: What is its clinical application and effectiveness in different continents? – A scoping review. *Journal of Conservative Dentistry and Endodontics*, *27*, 134–139. doi:10.4103/JCDE.JCDE_274_23

[31] Sibai, N., AlFadhel, R., Alsaleh, L., Durayhim, S. B., Almthen, H., & AlSewailem, L. (2023). Knowledge and Clinical Practice of Restoration Repair among Dental Undergraduate Students in the Kingdom of Saudi Arabia. *The Open Dentistry Journal*. doi:10.2174/18742106-v17-e230413-2022-171

[32] Almaghrabi, M., Albadawi, E., Dahlan, M., Aljohani, H., Ahmed, N., & Showlag, R. (2022). Exploring Parent's Satisfaction and the Effectiveness of Preformed Metal Crowns Fitting by Hall Technique for Carious Primary Molars in Jeddah Region, Saudi Arabia: Findings of a Prospective Cohort Study. *Patient Preference and Adherence*, *16*, 2497–2507. doi:10.2147/PPA.S370159

[33] Fatima, N., Mustilwar, R., Paul, R., Chauhan, P., Mostafa, D., & Dhopte, A. (2022). Minimal invasive dentistry. *International Journal of Health Sciences*. doi:10.53730/ijhs.v6ns1.8280

[34] Jeffrey, & Sugiaman, V. (2022). Approach to clinical laser application in pediatric dentistry. *Makassar Dental Journal*. doi:10.35856/mdj.v11i3.648

[35] Sharma, P., Dhawan, P., Rajpal, S., & Bhagat, N. (2021). Minimal Invasive Dentistry: An Emerging Trend. *International Journal of Medical Science And Diagnosis Research*. doi:10.32553/ijmsdr.v5i10.862

[36] Meinzer, A., Alkatout, I., Krebs, T., Baastrup, J., Reischig, K., Meikšāns, R., & Bergholz, R. (2020). Advances and Trends in Pediatric Minimally Invasive Surgery. *Journal of Clinical Medicine*, *9*. doi:10.3390/jcm9123999

[37] Kher, M., & Rao, D. A. (2019). *Contemporary Treatment Techniques in Pediatric Dentistry*. doi:10.1007/978-3-030-11860-0

[38] Alshamrani, A., & Alzahrani, F. (2024). Knowledge, Attitude and Practice of Green Dentistry among Dental Professionals in Saudi Arabia: A Cross-sectional Study. *Journal of Dental Science Research Reviews & Reports*. doi:10.47363/jdsr/2024(6)166

[39] Alenezi, Y., Abdulraheem, A., & Abdulraheem, K. (2024). Materials and Techniques for Pediatric Restorative Dentistry: A Review of the Latest Trends. *International Journal of Innovative Research in Engineering & Multidisciplinary Physical Sciences*. doi:10.37082/ijirmps.v12.i4.230955

[40] Kotlow, L. (2004). Lasers in pediatric dentistry. *Dental Clinics of North America*, *48 4*, 889–922. doi:10.1016/J.CDEN.2004.05.005

[41] Karlinsey, R. (2017). Emphasizing Minimally Invasive Strategies for Improved Dental Care of Children. *viXra*, 1–3. doi:10.15226/jdodt.2017.00178

[42] Bhatiya, P., & Thosar, N. (2015). Minimal invasive dentistry - An emerging trend in pediatric dentistry: A review. *International Journal of Contemporary Dental and Medical Reviews*, *2015*. Retrieved from https://consensus.app/papers/minimal-invasive-dentistry-an-emerging-trend-in-pediatric-bhatiya-thosar/41bb5484b8e6518ca97dcca6901ee475/

[43] Ezzeldin, T., Al-Awasi, K., Bader, R., Alshaikhi, A., Hakami, A., Siddiqui, I., … Alsubaie, T. (2021). A Study to assess the awareness and use of Silver Diammine Fluoride and Hall Technique among dental professionals and dental students in the Eastern Province. *The Saudi Dental Journal*, *33*, 1166–1173. doi:10.1016/j.sdentj.2021.01.005

[44] Alharbi, M., Aldosari, A., Almuhrij, H. A., Samman, H., Alwatban, N., Abaalkhail, N., … Ansari, S. (2019). *Behavioral Challenges Faced by General Dental Practitioners in the Treatment of Pediatric Patients; A Cross-sectional Study Done in Saudi Arabia*. *5*, 112–116. Retrieved from https://consensus.app/papers/behavioral-challenges-faced-by-general-dental-alharbi-aldosari/0f0860137ea05ac3a1c67feb49ead4ed/

[45] Mirsiaghi, F., Leung, A., Fine, P., Blizard, R., & Louca, C. (2018). An investigation of general dental practitioners' understanding and perceptions of minimally invasive dentistry. *BDJ*, *225*, 420–424. doi:10.1038/sj.bdj.2018.744

[46] Leal, S. (2014). Minimal intervention dentistry in the management of the paediatric patient. *BDJ*, *216*, 623–627. doi:10.1038/sj.bdj.2014.449

[47] Abushal, M., & Adenubi, J. (2003). Attitudes of Saudi parents toward behavior management techniques in pediatric dentistry. *Journal of Dentistry for Children*, *70 2*, 104–110. Retrieved from https://consensus.app/papers/attitudes-of-saudi-parents-toward-behavior-management-abushal-adenubi/425c395e91e15c9997e08a88ea5ccff1/

[48] Elson, N., & Brandes, I. (2017). Achieving Aesthetic Results by Using Laser in Minimally Invasive Dentistry Approach. *The American Journal of Cosmetic Surgery*, *34*, 123–128. doi:10.1177/0748806817692690

[49] Murdoch-Kinch, C., & McLean, M. (2003). Minimally invasive dentistry. *Journal of the American Dental Association*, *134 1*, 87–95. doi:10.14219/JADA.ARCHIVE.2003.0021

[50] Kumar, S., Mala, N., Rana, K., Namazi, N., Rela, R., & Kumar, K. (2021). Cognizance and Use of Minimally Invasive Dentistry Approach by General Dentists: An Overlooked Companion. *Journal of Pharmacy & Bioallied Sciences*, *13*. doi:10.4103/jpbs.JPBS_674_20

[51] Gujjar, K., & Sumra, N. (2013). *Minimally Invasive Dentistry - A Review*. Retrieved from https://consensus.app/papers/minimally-invasive-dentistry-a-review-gujjar-sumra/bce6e0b193155a58b294921ea137c747/

[52] Al-Fouzan, K. (2010). A survey of root canal treatment of molar teeth by general dental practitioners in private practice in Saudi Arabia. *The Saudi Dental Journal*, *22 3*, 113–117. doi:10.1016/j.sdentj.2010.04.003

[53] Malterud, M. (2006). Minimally invasive restorative dentistry: a biomimetic approach. *Practical Procedures & Aesthetic Dentistry : PPAD*, *18 7*, 409–414. Retrieved from https://consensus.app/papers/minimally-invasive-restorative-dentistry-a-biomimetic-malterud/10344cf1da725bbd83d38aef2797a379/

[54] Kohli, N., Hugar, S., Soneta, S., Saxena, N., Kadam, K., & Gokhale, N. (2022). Psychological behavior management techniques to alleviate dental fear and anxiety in 4–14-year-old children in pediatric dentistry: A systematic review and meta-analysis. *Dental Research Journal*, *19*. doi:10.4103/1735-3327.346405

[55] Dewi, A., Wicaksono, D. P., Sinaredi, B., Nastiti, R. B., Luthfiani, T. F., & Ardiana, T. F. (2023). MID (Minimal Intervention Dentistry) by Pediatric Dentist Specialist in City of Surabaya during the COVID-19 Pandemic. *Journal of Indonesian Dental Association*. doi:10.32793/jida.v6i1.997

[56] Gupta, C., Naik, S. S., & Hegde, S. (2024). Application of Modern Technology in Minimal Invasive Dentistry - A Narrative Review. *Journal of Electrical Systems*. doi:10.52783/jes.3280

[57] Giacaman, R., Muñoz-Sandoval, C., Neuhaus, K., Fontana, M., & Chałas, R. (2018). Evidence-based strategies for the minimally invasive treatment of carious lesions: Review of the literature. *Advances in Clinical and Experimental Medicine : Official Organ Wroclaw Medical University*, *27 7*, 1009–1016. doi:10.17219/acem/77022

[58] Staxrud, F. (2007). Minimally Invasive Dentistry. *Aktuel Nordisk Odontologi*. doi:10.18261/issn.2058-7538-2020-01-18

[59] Christensen, G. (2005). The advantages of minimally invasive dentistry. *Journal of the American Dental Association*, *136 11*, 1563–1565. doi:10.14219/JADA.ARCHIVE.2005.0088

[60] Azz, A., M, Abdulgani, & M, Abu-Hussein. (2024). Minimally Invasive Approach for Anterior Dental Aesthetics: Case Report. *Journal of Medical and Dental Science Research*. doi:10.35629/076x-11083136

[61] AlShuraiqi, Z., AlOlayan, F., & H. Osman, D. K. (2016). AWARENESS AND ATTITUDE TOWARD PULP THERAPY OF THE PRIMARY TEETH AMONG PARENTS IN QASSIM PROVINCE, KINGDOM OF SAUDI ARABIA. *International Journal of Approximate Reasoning*, *4*, 1322–1329. doi:10.21474/IJAR01/1931

[62] Alnahwi, T. H., Alhamad, M., Majeed, A., & Nazir, M. (2018). Management preferences of deep caries in permanent teeth among dentists in Saudi Arabia. *European Journal of Dentistry*, *12*, 300–304. doi:10.4103/ejd.ejd_397_17

[63] Sabbagh, H., Turkistani, J., Alotaibi, H., Alsolami, A., Alsulami, W., Abdulgader, A., & Bagher, S. (2021). *CCIDE_A_340158 531..539*. Retrieved from https://consensus.app/papers/ccidea340158-531539-sabbagh-turkistani/1f1620038dff5afc82919b89abd08e67/

[64] De Oliveira, L. M., Santos, P., Reis, M. C. V. D., & Kassis, E. (2022). Major clinical findings of minimally invasive surgery in dentistry: a systematic review. *MedNEXT Journal of Medical and Health Sciences*. doi:10.54448/mdnt22s309

[65] Moaleem, M. A., Ahmari, N. A., Alqahtani, S., Gadah, T., Jumaymi, A., Shariff, M., … Koreri, N. (2023). Unlocking Endocrown Restoration Expertise Among Dentists: Insights from a Multi-Center Cross-Sectional Study. *Medical Science Monitor : International Medical Journal of Experimental and Clinical Research*, *29*. doi:10.12659/MSM.940573

[66] Sarapultseva, M., & Sarapultsev, A. (2024). Comprehensive dental care in patient with Rubinstein-Taybi syndrome: A 3-year case study using progressive desensitization techniques and oral sedation. *Special Care in Dentistry : Official Publication of the American Association of Hospital Dentists, the Academy of Dentistry for the Handicapped, and the American Society for Geriatric Dentistry*. doi:10.1111/scd.13050