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MINIMALLY INVASIVE PEDIATRIC DENTISTRY: SIMPLICITY AND EFFECTIVENESS

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Abstract

Dental caries is the most prevalent non-communicable disease in children worldwide, significantly affecting their health and quality of life. Conventional restorative treatments are often invasive, anxiety-inducing, and require substantial removal of tooth structure. Minimally invasive approaches, including Atraumatic Restorative Treatment (ART), Interim Therapeutic Restoration (ITR), Silver Diamine Fluoride (SDF), Silver-Modified ART (SMART), and the Hall Technique, have emerged as effective alternatives. These methods aim to preserve tooth structure, reduce dental anxiety, and simplify treatment delivery. This narrative review discusses the principles, clinical applications, advantages, limitations, and current recommendations of these techniques in pediatric dentistry, highlighting their role in improving patient-centered care and promoting long-term oral health. This review provides a novel comparative synthesis of five key minimally invasive techniques, evaluating their integrated efficacy and patient-centered benefits to offer a unified framework for pediatric dental care, a perspective currently fragmented in the literature.

Keywords: Pediatric dentistry, minimally invasive dentistry, Atraumatic Restorative Treatment, Interim Therapeutic Restoration, Silver Diamine Fluoride (SDF), Hall Technique**.**

Introduction:

Dental caries is the most prevalent non-communicable disease in children, affecting over 600 million individuals worldwide, with the highest burden in socioeconomically disadvantaged regions [17]. Early Childhood Caries (ECC) is defined as the presence of decayed, missing, or filled tooth surfaces in children under six years of age [17].
Pediatric patients present unique challenges due to their developmental stage, fear of dental procedures, and limited cooperation. Conventional invasive treatments, such as drilling and filling, often increase anxiety and avoidance behaviors, which may contribute to the progression of untreated dental conditions [16].
Minimal Intervention Dentistry (MID), also referred to as ultra-conservative or micro-invasive dentistry, focuses on preserving tooth tissue, maintaining primary teeth until natural exfoliation, and applying preventive techniques, including sealing, infiltration, and minimally invasive restorative procedures [16].
This review aims to present and discuss the main minimally invasive techniques in pediatric dentistry, including Atraumatic Restorative Treatment (ART), Interim Therapeutic Restoration (ITR), Silver-Modified ART (SMART), Silver Diamine Fluoride (SDF), and the Hall Technique. Emphasis is placed on preserving tooth structure, minimizing patient anxiety, and providing effective caries control.

Minimally Invasive Approaches

Atraumatic Restorative Treatment (ART)

ART is a minimally invasive technique designed to prevent and arrest dental caries. The procedure involves the removal of soft, demineralized carious tissue using hand instruments, followed by restoration with an adhesive material that seals pits and fissures [8]. ART sealants often use high-viscosity glass ionomer cement (GIC) applied with finger pressure [3].

Initially developed for remote and developing regions, ART is now widely used for children, anxious patients, and individuals with special healthcare needs. Its non-aerosol-generating nature has proven especially valuable during the COVID-19 pandemic [4]. ART shows survival rates of 75–85% in primary teeth over three years, comparable to conventional restorations [2]. In permanent teeth, three-year success rates reached 93% for single-surface and 80% for multiple-surface cavities [9].

ART is indicated when conventional dental treatment is not feasible due to accessibility limitations and can be employed in schools as a community-based caries control measure. It is suitable for both primary and permanent teeth [18][7].

IAPD Recommendations on ART

- ART is appropriate for single-surface cavities in primary and permanent teeth.
- It should be avoided in teeth with deep caries near the pulp, pulpal exposure, or signs of irreversible pulpitis or abscess, especially when radiographs are unavailable.
- Advantages include low cost, minimal trauma, and no need for local anesthesia, making it ideal for young, uncooperative, or special-needs patients.
- High-viscosity GIC is preferred due to its biocompatibility, chemical bonding, fluoride release, and durability.

- Survival rates for multi-surface ART restorations in posterior teeth are lower [19].

Interim Therapeutic Restoration (ITR)

ITR is a temporary restorative technique based on ART principles. Carious tissue is removed with hand or rotary instruments and restored with GIC or resin-modified GIC (RMGIC). This approach not only restores tooth structure but also reduces cariogenic bacteria and helps rebalance the oral microflora [7]. ITR is recommended for temporary caries control, particularly in young, uncooperative, or special-needs children, as well as in cases of early childhood caries, stepwise excavation, or when traditional dental treatment cannot be immediately performed. Definitive restoration should follow within six months to prevent the return of oral microbes to pre-treatment levels and reduce the risk of restoration failure [20].

Silver Diamine Fluoride (SDF)

SDF combines the antibacterial properties of silver with the remineralizing effects of fluoride, offering a dual approach to arrest and prevent caries [13]. Studies have demonstrated that SDF effectively arrests caries progression in 80-90% of treated lesions, making it as one of the most efficacious minimally invasive strategies for caries management [12]. Its ease of use, low cost, and noninvasive application make it particularly valuable for high-caries-risk pediatric patients, children with special healthcare needs, or anxious patients [13].

Mechanistically, SDF forms a protective layer of silver-protein complexes that inhibit bacterial activity, while fluoride ions enhance enamel remineralization [21]. A survey reported that 56% of parents expressed reservations about SDF, particularly for anterior teeth [14]. However, after being informed of its caries-arresting benefits and role in reducing invasive treatments, 76% accepted its use on posterior teeth [5], with acceptance further improving when presented as an alternative to sedation or general anesthesia for anxious or behaviorally challenged children [5].

Silver-Modified ART (SMART)

The SMART technique integrates SDF with ART principles. After enamel access, carious lesions are arrested using SDF, followed by restoration with resin-modified glass ionomer. SDF may be applied immediately before restoration or after a few days to allow caries arrest, reduction in sensitivity, or adaptation to the dental environment. This method can slow caries progression and reduce the risk of irreversible pulpitis [10]. This technique addresses parental aesthetic concerns associated with SDF while maintaining its clinical efficacy in caries arrest.[5]

Hall Technique

The Hall Technique is a noninvasive method for managing caries in primary molars using preformed metal crowns (PMCs). Introduced by Dr. Norna Hall in 2006, it involves placing a crown without local anesthesia, caries removal, or tooth preparation. The selected PMC is filled with GIC and seated over the carious molar using finger pressure or the child's biting force [6][1].

This technique seals cavities without mechanical excavation, preserves the vital pulp, alters plaque to a less cariogenic composition, and can arrest or slow caries progression [16][15].

Clinical studies report a 97% five-year survival rate, exceeding outcomes of pulpotomy and composite restorations, and it is particularly suitable for anxious children while increasing operator comfort [11].

IAPD Recommendations for Hall Technique

- Indications: Anxious children, primary teeth with deep or multi-surface caries without pulpal involvement, or when conventional equipment is unavailable (71%).

- Drawbacks: May require prior separator placement, temporary occlusal changes, and sometimes less accurate crown adaptation (82%).

- Effectiveness: Longevity comparable to conventional methods (76%).
- Alternative: Conventional PMC preparation may be preferable for multi-surface lesions to ensure optimal adaptation and occlusion (70%) [22].

Discussion

Minimally invasive approaches in pediatric dentistry provide a paradigm shift from traditional, restorative-centered care to patient-centered, preventive-oriented treatment. Techniques such as ART, SMART, SDF, and the Hall Technique offer several significant advantages [4]. First, they are **simple and efficient**, often requiring minimal equipment, limited chair time, and easy-to-learn protocols, making them suitable for a wide range of clinical settings, including community and school-based programs [7][19].

Second, these approaches contribute to **reducing dental anxiety and fear** in children. By avoiding rotary instruments, local anesthesia, and extensive tooth preparation, procedures become less intimidating, enhancing cooperation and improving the overall dental experience. Early positive experiences may also influence children's long-term attitudes toward dental care [16].

Third, **tooth structure preservation** is a central advantage. By minimizing the removal of healthy dentin and enamel, these techniques help maintain pulp vitality, support natural exfoliation of primary teeth, and reduce the risk of procedural complications [6][1]. This aligns with the principles of Minimal Intervention Dentistry, emphasizing tissue preservation and the management of caries as a dynamic, reversible process rather than immediately resorting to invasive restorations [16].

Despite these strengths, some **limitations** must be considered. The esthetic outcome of SDF, particularly its black staining effect, may be a concern for both parents and children, requiring careful counseling before application [13]. Additionally, minimally invasive treatments generally **require follow-up** to ensure lesion arrest, restoration integrity, and to monitor for progression of untreated caries [10]. Parental understanding and engagement are critical for adherence to preventive instructions and recall visits, which can influence treatment success [16].

On the other hand, the has contextual limits. For exemple, ART research comes from low- and middle-income or underserved settings. While this shows feasibility and effectiveness, its direct

applicability to diffrent contexts remains uncertain. IAPD guidelines note this variability but stress that evidence from diverse contexts should inform practice. More research across socioeconomic and geographic settings is needed to strengthen external validity [19].

Importantly, these approaches should **complement rather than replace** conventional care. Multi-surface lesions, extensive decay, or pulpal involvement may still necessitate traditional restorative procedures [19]. Nevertheless, the integration of minimally invasive techniques into routine pediatric practice allows clinicians to **individualize care**, prioritize patient comfort, and extend preventive interventions to populations with limited access to dental care. The importance of studying the practical difficulties to implement these strategies [2].
This review has also inherent methodological limitations. As a narrative synthesis, the selection of included studies was not conducted through a systematic protocol with predefined search criteria, introducing potential **selection bias**. Another limit is the absence of structured quality assessment tools and the lack of **quantitative synthesis** (meta-analysis). As a consequence, the conclusions reflect qualitative interpretation, which may affect the strength and generalizability of the findings.
Beyond efficacy, adopting minimally invasive strategies requires addressing practical barriers. Limited training during dental education means postgraduate courses or workshops are often needed to build competence. Cost-effectiveness studies, particularly for publicly funded systems, are vital to guide policy and reimbursement. Evidence on economic impact, time efficiency, and long-term outcomes compared with conventional care will support integration. Finally, factors like material availability, infection control, and patient acceptance must be studied to ensure sustainable real-world use.

In summary, minimally invasive approaches bridge the gap between effective caries management and child-centered care, offering sustainable, evidence-based alternatives that align with contemporary preventive dentistry principles. Despite that their growing adoption depends on adequate training, cost-effectiveness, and practical feasibility in real-world settings. It still reflects a shift toward **early intervention, preservation of tooth structure, and enhancement of patient experience**, which are essential for promoting oral health in children [13][15][17]. doption of minimally invasive strategies depends on adequate training, cost-effectiveness, and practical feasibility in real-world settings [1].

Conclusion

Minimally invasive treatments such as ART, SMART, SDF, and the Hall Technique represent effective alternatives for pediatric dental care. Individualized diagnosis, treatment planning, and follow-up are crucial to ensure optimal outcomes. Future perspectives include wider integration into daily practice, improved materials, and longitudinal studies to strengthen evidence for long-term effectiveness.

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