# A Scoping Review of the Silver-Modified Atraumatic Restorative Technique (SMART)

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## ABSTRACT

**Purpose:** As minimally invasive dentistry becomes more prevalent in the face of mounting treatment needs in children, the silver-modified atraumatic restorative technique (SMART) has become a compelling option for the pediatric dentist. The purpose of this review is to identify and evaluate existing clinical trials involving SMART to better gauge its utility in the pediatric dentist's armamentarium.

**Methods:** A search was conducted in four databases (Medline/PubMed, Embase, the Cochrane Library and Dentistry & Oral Sciences Source) and a scoping review was performed following the PRISMA Extension for Scoping Reviews checklist.

**Results:** From a total of 724 references, 94 articles were assessed for eligibility and 12 were included in the review. For both clinical and radiographic outcomes, this review shows that SMART demonstrates comparable survival rates when compared to stainless steel crown (SSC) or Hall technique (HT) treatments and seems to outperform ART alone. In addition, for other clinical factors such as caries incidence, patient acceptance, treatment time, and cost per treatment, SMART again outperforms ART alone.

**Conclusions:** Existing clinical trials suggest there is no difference in clinical success when SMART is evaluated against conventional treatment (SSC or HT). The preponderance of current research suggests that for both clinical and radiographic outcomes, SMART appears to outperform ART alone and, ultimately, is a viable treatment option for treating early childhood caries (ECC).

## INTRODUCTION

Despite a recent decline in the prevalence of dental caries among school-aged children in the United States, over the past 25 years, caries prevalence has not improved for the global population.[1,2] As such, dental caries has persisted as the most common chronic disease affecting children worldwide, estimated to afflict almost half of all school-aged children.[3,4] While long-practiced, traditional restorative techniques may offer favorable success and survival rates, these treatments are often deemed unsuitable due to the pervasive behavioral and financial barriers encountered in the pediatric population.[5]

Although minimally invasive restorative options have expanded the arsenal available to treat caries in children, they all present with unique disadvantages. Despite increased acceptance among patients, ART and ITR are shown to have higher rates of restoration failure than conventional restorative treatments.[6,7] While Hall crowns demonstrate compelling success rates, for teeth with questionable pulpal status, a full-coverage or definitive restoration is often contraindicated.[8]

For SDF, the most glaring drawback is the resultant staining of carious tooth structure.[9-12] In addition, while the liquid format of SDF lends to its ease of placement and patient acceptance, it does not restore lesions presenting with frank cavitation.[13] To that end, research indicates that SDF has significantly lower rates of success for larger and posterior carious lesions.[14-15] It is speculated that since cavitated lesions are more difficult to clean and more prone to food impaction, if the clinical microenvironment is not corrected, the caries cycle will not be broken.[16-17]

In summary, despite an array of treatment modalities, gaps still exist between the limitations for one technique and the indications for another. As a result, the silver-modified atraumatic restorative technique (SMART) has garnered support.[18] As its name suggests, SMART involves the application of SDF to carious tissue followed by restoration with a glass ionomer cement.[18] Although clinical trials have shown promising results, to date, there has not been a review completed on the existing trials involving SMART. Likewise, the purpose of this research project is to perform a scoping review on SMART that examines existing clinical trials, aggregates evidence and identifies research gaps to translate literature into clinical practice and guide future research endeavors.

## MATERIALS AND METHODS

A scoping review was performed to synthesize and assess published clinical trials using SMART. This review follows the PRISMA Extension for Scoping Reviews checklist.[19]

***Eligibility Criteria***

Any clinical trial which examined SMART compared to a conventional treatment option (defined as SDF alone, ART/ITR alone, glass ionomer/composite restoration with/without caries removal, or stainless steel crown with/without caries removal) was eligible for inclusion. Exclusion factors included: a) inconsistent definition of SMART; b) no follow-up assessment; c) lack of control/comparison group. In addition, studies that were not published in English, and those which lacked sufficient description of protocols, methods, or data extraction were also excluded from review.

***Search Strategy***

A literature search was conducted on four electronic databases: Medline/PubMed, Embase, the Cochrane Library and Dentistry & Oral Sciences Source. Searches included English language studies published from 1990 to present day. The initial search period began on 15 January 2024 with the final search executed on 31 August 2024. The full search strategies are included an appendix that is available upon request.

***Selection & Data***

Any studies not meeting the clinical trial criteria (e.g., case series, expert opinions, policy documents) were excluded. Eligible studies were catalogued in an Excel spreadsheet, recording publication year, study type, participant details (number, age range), tooth type treated, ICDAS classification (if available), control group/treatment, dependent variable, and follow-up interval. Duplicates were removed. Two reviewers (KM and NT) independently screened the articles, resolving conflicts through discussion. Data charting was done by NT and reviewed by KM. No quality appraisal was performed, as the review aimed to summarize existing literature for future research. Study data was managed by the principal investigator (KM) for quality control, with access restricted to the investigators (KM and NT). See Table 1.

**TABLE 1. SMART Articles Included in Review**

| Reference | Objective | Methods | Results |
|---|---|---|---|
| Ahmad et al., (2022)[20] | Radiographic outcomes of SMART vs. ART | 21 children with carious primary molars in a split-mouth design (SMART, n = 21; ART, n = 21) Follow-up at 3 months. | SMART shows a significantly greater increase in radiodensity compared to the ART group ($P$< .001). |
| Ahmad et al., (2022)[21] | Parental satisfaction of SMART vs. ART | 21 children with carious primary molars in a split-mouth design (SMART, n = 21; ART, n = 21) Follow-up post-operatively. | SMART treatment was simpler, faster and more tolerable than ART ($P$< .001). No difference in parental opinion of performance or esthetics. |
| Aly et al., (2023)[22] | Clinical outcomes & cost effectiveness of SMART vs. ART | 67 children with a carious primary molar (SMART, n = 34; ART, n = 33) Follow-up at 6 and 12 months. | No difference in clinical outcomes at 6 or 12 months ($P$= .416). SMART was significantly faster and economical than ART ($P$< .001). |
| Bansal et al., (2023)[23] | Clinical outcomes of SMART vs. conventional (Drill & fill) | 226 children with carious primary molars (SMART, n = 112; conventional, n = 114) Follow-up at 24 months. | No difference in the success rates of SMART to conventional ($P$= .105). SMART was significantly more tolerable ($P$< .001). |
| Erbas Unverdi et al., (2024)[24] | Clinical outcomes of SMART vs. SDF | 48 children with carious permanent molars in a split-mouth design (SMART, n = 56; SDF, n = 56) Follow-up at 1, 6, 12, 18, 24 and 36 months. | SMART treatment shows significantly greater rate of caries preventive effect than SDF alone ($P$< .001). |
| Jasim & Khalaf, (2023)[25] | Microleakage of SMART vs. GIC alone | 32 extracted primary molars randomized into two groups (SMART, n = 16; GIC, n = 16) | No difference in microleakage between groups ($P$> .05). Delayed restoration shows less microleakage than immediate restoration ($P$= .003). |
| Mohammed et al., (2022)[26] | Clinical outcomes of SMART vs. ART | 30 children with carious primary molars in a split-mouth design (SMART, n = 30; ART, n = 30) Follow-up at 6 and 12 months. | SMART shows higher success rates at 6 and 12 months, though not significant ($P$= .559, $P$= .969). |
| Patel et al., (2022)[27] | Clinical outcomes of SMART vs. conventional vital pulp therapy | 60 children with carious primary molars (SMART, n = 30; conventional, n = 30) Follow-up at 3, 6, and 12 months. | No difference in clinical or radiographic outcomes between groups at 3, 6, or 12 months ($P$> .05). |
| Patel et al., (2023)[28] | Clinical outcomes of SMART vs. resin-based sealants | 66 children with carious molars in a split-mouth design (SMART, n = 66; resin sealant, n = 66) Follow-up at 3, 6, and 12 months. | SMART shows a significantly lower rate of caries incidence ($P$= .041). Resin sealants show greater retention than SMART sealants ($P$= .02). |
| Powell et al., (2024)[29] | Microleakage of SMART vs. ART | 60 extracted permanent molars randomized into four groups (two SMART, n = 15; two ART, n = 15) | No difference in microleakage between groups ($P$> .05). |
| Shawki et al., (2023)[30] | Clinical & radiographic outcomes of SMART vs. Hall Technique vs. conventional (Drill & fill) | 90 children with carious primary molars (SMART, n = 30; HT, n = 30; conventional, n = 30) Follow-up at 1, 3 and 6 months. | SMART and HT groups show significantly greater radiographic success rate than the conventional group ($P$= .009). |
| Velagala et al., (2023)[31] | Microtensile bond strength of SMART vs. GIC alone | 40 extracted primary molars randomized into two groups (SMART, n = 20; GIC, n = 20) | No difference in microtensile strength or type for failure between groups ($P$= .625, $P$= .575). |

*SMART= Silver-Modified Atraumatic Restorative Technique; ART= Atraumatic Restorative Technique; SDF= Silver Diamine Fluoride; GIC= Glass Ionomer Cement; HT= Hall Technique*

## RESULTS

Outcomes in the review were categorized into clinical, radiographic, and laboratory outcomes. Four studies found no difference in success rates between the SMART group and conventional/control groups (e.g., SSC, ART, SDF) at follow-up.[22,23,26,27] Shawki et al. (2023) reported that while the Hall crown technique had the highest success rate at 6 months, SMART outperformed ART alone ($P$= .025).[30] Patel et al. (2023) found that SMART sealants had a lower caries incidence ($P$= .041).[28] Erbas Unverdi et al. (2024) also found SMART-treated teeth had lower caries incidence than SDF alone ($P$< .05).[24]

In addition, Ahmad et al. (2022) and Bansal et al. (2023) found greater patient tolerance for SMART compared to the control ($P$< .001).[21,23] Ahmad et al. (2022) also noted significantly shorter treatment time for SMART compared to ART alone ($P$< .001), with no differences in parental attitudes or esthetic concerns ($P$> .05).[21] Aly et al. (2023) reported lower treatment costs and shorter treatment time for SMART restorations ($P$< .001).[22]

For radiographic outcomes, Patel et al. (2022) found no significant difference in radiographic failure between SMART and conventional (SSC) groups ($P$> .05).[27] Shawki et al. (2023) found no difference in radiographic failure between SMART and Hall crown groups ($P$> .05), but noted higher failure rates in the ART group ($P$= .009).[30] Ahmad et al. (2022) reported greater increase in radiodensity in the SMART group compared to ART alone ($P$< .001).[20]


**Figure 1. SMART Treatment:** (A) Pre-operative untreated carious lesion. (B) Carious lesion following SDF application. (C) Lesion restored with GIC.

## CONCLUSIONS

Based on this study's results, the following conclusions can be made:

- SMART demonstrates no significant difference in clinical success and survival rates when assessed against conventional treatment (SSC or HT).
- SMART consistently outperforms ART alone both in clinical success and supplementary clinical outcomes such as treatment time, cost, and post-operative radiodensity.
- While additional clinical trials and systematic reviews are necessary to further elucidate the indications, success and longevity of SMART, the existing literature summarized in this scoping review supports the implementation of SMART into the pediatric dentist's armamentarium for treating caries.

## BIBLIOGRAPHY

References available upon request.