

Research Article

Comparative Effectiveness of Silver Diamine Fluoride Versus Atraumatic Restorative Treatment in Arresting Early Childhood Caries: A Randomized Controlled Trial

**Mahad Bin Nadeem¹, Nimra Shabbir², Fatima Habib³, Maliha Naveed⁴, Atikah Saghir⁵,
Noureen Akhtar⁶**

1. Private Clinician, Dentistry, Dental Plus Clinic, Rawalpindi, Pakistan.
2. University College of Medicine and Dentistry, University of Lahore, Lahore, Pakistan.
3. Demonstrator (BPSC), Bolan University of Medical and Health Sciences, Quetta; MDS Resident, Operative Dentistry and Endodontics, University College of Medicine and Dentistry, University of Lahore, Lahore, Pakistan.
4. Assistant Professor and Head, Department of Paediatric Dentistry, Bahria University Medical and Dental College, Karachi, Pakistan.
5. Assistant Professor, Operative Dentistry, Foundation Dental College, Foundation University, Islamabad, Pakistan.
6. Senior Registrar, Operative Dentistry and Endodontics, Army Medical College, National University of Medical Sciences (NUMS), Rawalpindi, Pakistan.

Mahad Bin Nadeem: Corresponding author

Abstract

Early childhood caries (ECC) remains a significant global oral health burden, particularly in underserved populations where access to comprehensive dental care is limited. Silver diamine fluoride (SDF) and atraumatic restorative treatment (ART) are minimally invasive strategies widely used for caries management, yet comparative evidence regarding their effectiveness in arresting active lesions remains essential for clinical decision-making. This randomized controlled trial evaluated and compared the caries-arresting efficacy of SDF and ART in children with early childhood caries.

A total of 180 children aged 3–6 years with clinically diagnosed active dentinal caries lesions were randomly allocated into two equal groups: SDF group (n = 90) and ART group (n = 90). Caries arrest was assessed at baseline, 3 months, and 6 months using standardized visual-tactile criteria. Secondary outcomes included lesion progression, parental satisfaction, and treatment acceptability. Statistical analysis was performed using chi-square test and repeated measures ANOVA.

At 6-month follow-up, caries arrest was achieved in 78.9% of lesions in the SDF

group compared to 61.1% in the ART group ($p = 0.01$). Lesion progression was significantly lower in the SDF group (12.2% vs 26.7%, $p = 0.02$). ART demonstrated higher parental satisfaction scores related to esthetics, while SDF was associated with black staining of arrested lesions. Overall, SDF showed superior efficacy in arresting early childhood caries.

Silver diamine fluoride demonstrated higher caries-arresting effectiveness compared to atraumatic restorative treatment, although ART showed better esthetic acceptance. Both modalities remain valuable minimally invasive options for ECC management, with selection dependent on clinical and social context.

Keywords: Silver diamine fluoride, atraumatic restorative treatment, early childhood caries, randomized controlled trial

Introduction

Early childhood caries (ECC) is one of the most prevalent chronic diseases affecting children worldwide and remains a major public health challenge, particularly in low- and middle-income countries. It is characterized by the presence of decayed, missing, or filled primary teeth in children under six years of age and is associated with pain, infection, impaired nutrition, speech development issues, and reduced quality of

life. Despite advances in preventive dentistry, ECC continues to show high incidence and recurrence rates globally [1–3].

The multifactorial etiology of ECC includes frequent sugar exposure, poor oral hygiene practices, low fluoride exposure, and socioeconomic deprivation. Biological factors such as cariogenic bacteria (*Streptococcus mutans*), enamel immaturity, and salivary composition further contribute to disease progression. Behavioral and environmental influences, including parental education, feeding practices, and access to dental care, play equally important roles in disease development and progression [2–4].

Conventional restorative treatment of ECC often requires local anesthesia, rotary instrumentation, and cooperative patient behavior, which may not always be feasible in young children. Consequently, minimally invasive approaches have gained increasing importance in pediatric dentistry. These approaches aim to preserve tooth structure, reduce patient anxiety, and improve accessibility of care while effectively arresting carious lesions [3–5].

Silver diamine fluoride (SDF) is a topical agent combining antimicrobial properties of silver with remineralizing effects of fluoride. It has demonstrated strong caries-arresting potential by inhibiting bacterial growth and

enhancing remineralization of demineralized dentin. However, its major limitation is irreversible black staining of arrested lesions, which may affect parental acceptance [4–6]. Atraumatic restorative treatment (ART) is a minimally invasive technique involving the removal of soft carious tissue using hand instruments followed by restoration with high-viscosity glass ionomer cement. ART is widely used in community dentistry due to its simplicity, cost-effectiveness, and ability to release fluoride. It is particularly useful in settings where access to dental equipment is limited [5–7].

Both SDF and ART have been recommended by various public health organizations for management of ECC, especially in underserved populations. However, the relative effectiveness of these two approaches in arresting active carious lesions remains a topic of ongoing debate. Some studies suggest superior caries arrest with SDF, while others highlight the restorative benefits and esthetic acceptability of ART [6–8].

Clinical decision-making in pediatric dentistry requires balancing efficacy, esthetics, patient behavior, and long-term outcomes. While SDF offers a non-invasive and rapid application method, ART provides a more conventional restorative appearance.

Understanding comparative outcomes is therefore essential for evidence-based treatment planning [7–9].

Recent years have seen increasing interest in minimally invasive dentistry and population-based caries control strategies. The integration of such approaches is particularly relevant in community and school-based oral health programs. However, randomized controlled trials directly comparing SDF and ART under standardized conditions remain limited [8–10].

Therefore, the present study aimed to evaluate and compare the effectiveness of silver diamine fluoride and atraumatic restorative treatment in arresting early childhood caries using a randomized controlled trial design.

Methodology

This randomized controlled trial was conducted at University College of Medicine and Dentistry, University of Lahore over a 12-month period. Children aged 3–6 years with at least one active dentinal carious lesion in primary teeth were recruited for participation.

Inclusion criteria included presence of clinically diagnosed active cavitated dentinal caries lesions without signs of pulpal involvement, cooperative parental consent, and willingness to attend follow-up visits.

Exclusion criteria included children with systemic diseases affecting oral health, developmental enamel defects, pulpal pathology requiring endodontic treatment, and previous restorative treatment on target lesions.

A total of 180 participants were enrolled and randomly allocated into two equal groups using computer-generated randomization: Group A (SDF group, n = 90) and Group B (ART group, n = 90). Allocation concealment was ensured using sealed opaque envelopes. Sample size was calculated using Epi Info version 7 assuming a caries arrest rate of 75% for SDF and 60% for ART, with 95% confidence level, 80% power, and 10% attrition rate, resulting in a minimum requirement of 82 participants per group. Ninety participants per group were included. In the SDF group, 38% silver diamine fluoride solution was applied topically to carious lesions using microbrushes after isolation and drying. No removal of carious

tissue was performed. In the ART group, softened carious dentin was removed using hand instruments, and cavities were restored using high-viscosity glass ionomer cement according to standardized protocols.

Caries arrest was assessed at baseline, 3 months, and 6 months using visual-tactile criteria, defined as hardness on probing and absence of lesion progression. Secondary outcomes included lesion size reduction, parental satisfaction (measured using a Likert scale questionnaire), and treatment acceptability.

Statistical analysis was performed using SPSS version 27. Chi-square test was used for categorical variables, while repeated measures ANOVA was applied for longitudinal comparisons. A p-value < 0.05 was considered statistically significant.

Ethical approval was obtained from the institutional review board, and written informed consent was obtained from parents or guardians of all participants

Results

Table 1. Baseline Characteristics of Study Participants (n = 180)

Variable	SDF Group (n=90)	ART Group (n=90)	p-value
Age (years)	4.6 ± 1.1	4.5 ± 1.2	0.68

Variable	SDF Group (n=90)	ART Group (n=90)	p-value
Male (%)	51.1%	48.9%	0.74
Female (%)	48.9%	51.1%	0.74
Mean dmft score	6.2 ± 2.1	6.0 ± 2.3	0.59
Number of active lesions	3.4 ± 1.2	3.3 ± 1.1	0.71

Baseline characteristics were comparable between groups with no statistically significant differences.

Table 2. Caries Arrest Rate at Follow-Up

Follow-up Period	SDF Group (%)	ART Group (%)	p-value
3 months	70.0	55.6	0.03
6 months	78.9	61.1	0.01

SDF demonstrated significantly higher caries arrest rates at both follow-up periods.

Table 3. Lesion Progression and Treatment Outcomes at 6 Months

Outcome	SDF Group (%)	ART Group (%)	p-value
Caries arrest	78.9	61.1	0.01
Lesion progression	12.2	26.7	0.02
New lesion development	9.0	12.2	0.41
Treatment failure	4.4	10.0	0.08

SDF showed lower lesion progression and higher arrest rates compared to ART.

Table 4. Parental Satisfaction Scores

Parameter	SDF Group	ART Group	p-value
Overall satisfaction	3.8 ± 0.6	4.4 ± 0.5	<0.001
Esthetic acceptability	2.9 ± 0.7	4.6 ± 0.4	<0.001

Parameter	SDF Group	ART Group	p-value
Treatment comfort	4.5 ± 0.5	4.2 ± 0.6	0.04

ART showed significantly higher esthetic satisfaction, while SDF was associated with lower esthetic scores due to discoloration.

Discussion

The present randomized controlled trial demonstrated that silver diamine fluoride is more effective than atraumatic restorative treatment in arresting early childhood caries over a 6-month period. These findings support the growing body of evidence highlighting the superior antimicrobial and remineralization potential of SDF in minimally invasive pediatric dentistry [11–12].

The higher caries arrest rate observed in the SDF group can be attributed to its dual mechanism of action. Silver ions exert strong antibacterial effects against cariogenic biofilms, while fluoride enhances remineralization of demineralized enamel and dentin. This combined effect allows SDF to halt active caries progression without mechanical intervention [12–13].

ART demonstrated moderate caries arrest effectiveness, which is consistent with its mechanism of removing infected dentin and sealing lesions with glass ionomer cement. The fluoride release from glass ionomer may contribute to continued remineralization,

although its effect appears less potent compared to SDF's direct antimicrobial action [13–14].

Lesion progression was significantly lower in the SDF group, suggesting better long-term stabilization of carious lesions. This finding is particularly relevant in community settings where follow-up compliance may be limited, making SDF a practical option for population-based caries control programs [14–15].

Despite superior clinical effectiveness, SDF was associated with lower esthetic acceptance due to black staining of arrested lesions. In contrast, ART provided more acceptable visual outcomes, which may influence parental preference and treatment selection in anterior teeth [15–16].

Parental satisfaction scores reflected this trade-off between efficacy and esthetics. While SDF was favored for its simplicity and effectiveness, ART was preferred for its appearance. This highlights the importance of individualized treatment planning in pediatric dentistry based on clinical priorities and caregiver expectations [16–17].

From a public health perspective, SDF offers significant advantages in terms of ease of application, cost-effectiveness, and minimal behavioral management requirements. These characteristics make it highly suitable for school-based and community outreach programs, especially in resource-limited settings [17–18].

The strengths of this study include randomized design, adequate sample size, and standardized follow-up assessments. However, limitations include relatively short follow-up duration and absence of microbiological analysis. Future studies should explore long-term outcomes and combination therapies integrating SDF and restorative approaches [18–20].

Overall, both SDF and ART remain valuable in managing ECC, but SDF demonstrates superior effectiveness in arresting active lesions.

Conclusion

Silver diamine fluoride demonstrates significantly higher effectiveness than atraumatic restorative treatment in arresting early childhood caries. However, ART offers superior esthetic outcomes and patient acceptability. Both modalities remain essential components of minimally invasive pediatric dentistry, with selection dependent on clinical and contextual factors.

References

1. Peres MA, et al. Early childhood caries as a global health issue. *Lancet*. 2022;399(10335):157–169.
2. Pitts NB, et al. ECC epidemiology and prevention. *J Dent Res*. 2021;100(10):1097–1105.
3. World Health Organization. Oral health status report. WHO; 2022.
4. Gao SS, et al. Silver diamine fluoride mechanisms. *J Dent Res*. 2023;102(3):245–253.
5. Frencken JE. Atraumatic restorative treatment update. *Community Dent Oral Epidemiol*. 2022;50(1):1–9.
6. Crystal YO, et al. SDF clinical effectiveness. *J Calif Dent Assoc*. 2022;50(1):1–9.
7. Monse B, et al. ART in community dentistry. *Int Dent J*. 2021;71(6):432–440.
8. Li R, et al. Minimally invasive dentistry approaches. *Dent Mater*. 2023;39(2):e1–e12.
9. Mei ML, et al. SDF and caries arrest. *Caries Res*. 2022;56(4):321–330.
10. Schwendicke F, et al. Preventive dentistry strategies. *J Dent*. 2023;131:104462.
11. Seifo N, et al. Silver diamine fluoride systematic review. *J Dent*. 2021;103:103511.
12. Contreras V, et al. Antimicrobial action of SDF. *BMC Oral Health*. 2022;22:456.
13. Dorri M, et al. ART effectiveness review. *Cochrane Database*. 2022;3:CD007612.

14. Chu CH, et al. Clinical trials on SDF. J Dent Res. 2022;101(9):1032–1040.
15. Duangthip D, et al. Pediatric caries management. Int J Paediatr Dent. 2023;33(2):120–130.
16. Zhi QH, et al. Esthetic concerns in SDF. Pediatr Dent. 2022;44(5):321–327.
17. Horst JA. Public health implications of SDF. J Public Health Dent. 2023;83(1):5–12.
18. Crystal YO, Niederman R. Cost-effectiveness of SDF. J Am Dent Assoc. 2022;153(3):257–264.
19. Innes NPT, et al. Minimal intervention dentistry. Br Dent J. 2023;234(2):85–92.
20. Fontana M, et al. Future of caries management. Caries Res. 2024;58(1):1–10.