Silver Diamine Fluoride for Prevention of Endodontic Treatment in Adults

A Clinical Perspective

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Silver diamine fluoride (SDF) represents a significant advancement in modern dentistry, offering practitioners a powerful tool to preserve tooth vitality and prevent the need for root canal treatment in adult patients with deep caries.[1,2] Although SDF received FDA clearance in 2014 for the treatment of dentinal hypersensitivity (DH), its international use spans more than five decades, with emerging evidence demonstrating exceptional capacity to arrest deep carious lesions and maintain pulp vitality in adults.[1,2] The COVID-19 pandemic served as a catalyst for widespread adoption, highlighting SDF's efficacy as a minimally invasive treatment modality that preserves tooth structure.[1] A retrospective case series of 277 adult teeth demonstrated that 95% did not require endodontic intervention over 16 months to 6 years of follow-up.[3] Recent cohort data confirm these findings: a two-year study in older adults showed that repeated SDF applications extended tooth survival nine-fold longer than single treatments.[4]

From historical development to pioneering research in Japan

Silver's antimicrobial properties have been recognized for centuries. Ancient Roman civilizations placed silver foil in wounds, and early American settlers dropped silver coins into water barrels to prevent microbial contamination. In dentistry, silver-based therapies emerged in the 1840s, when U.S. dentists employed silver nitrate ($AgNO_3$) as a caustic agent to cauterize carious lesions.[5]

The foundation for modern SDF was established when Dr. Mizuho Nishino conducted groundbreaking research at Osaka University investigating silver diamine fluoride as part of her doctoral thesis.[6] Nishino and Professor Yamaga Reiichin formulated a stable, bioavailable agent that combines silver's antimicrobial properties with fluoride's remineralizing effects while sealing dentinal tubules.[2,6] Their research, published in 1969 in the Journal of Osaka University Dental Society, established the SDF paradigm: synergistic antimicrobial action coupled with remineralization potential,

The formulation delivers approximately 253,870 ppm total silver concentration that exerts therapeutic effects while remaining below established toxicity thresholds.[9,14]

a mechanism particularly valuable in preserving compromised pulps in deep carious lesions.[6]

Evolution and global recognition

SDF gradually gained international recognition through key regulatory and professional milestones. The FDA cleared Advantage Arrest SDF in 2014 for dentinal hypersensitivity[1,7] and granted Breakthrough Therapy Designation in 2016 for caries arrest.[7] Health Canada approved SDF in 2017 for anti-caries management,[2] while the American Dental Association endorsed annual 38% SDF application for adults in 2020, recognizing superior efficacy compared to topical fluoride alternatives.[4] SDF received further global validation when the World Health Organization included it in the 2021 Model List of Essential Medicines.[8] One of the latest SDF products to enter the market, Centrix's SilverSense SDF demonstrates how this therapeutic category continues to evolve, offering practitioners modern formulations designed specifically for managing complex adult caries with minimally invasive, cost-effective approaches.

Chemical composition and formulation

The most commonly available SDF formulation in the U.S. is a 38% aqueous solution comprising 25% silver ions, 5.5% fluoride ions, and 8% ammonia as a stabilizer.[9,10] The ammonia maintains the diamine-silver complex in solution. This formulation results in an alkaline solution with a pH between 8 and 10, which promotes fluorapatite formation and enhances therapeutic efficacy.[11-13]

The formulation delivers approximately 253,870 ppm total silver concentration that exerts therapeutic effects while remaining below established toxicity thresholds.[9,14] SDF penetrates 25 micrometers into enamel and 200-300 micrometers into dentin, with silver ions penetrating even deeper. This allows SDF to reach carious bacteria while maintaining safety margins when protective dentin remains between the lesion and pulp tissue.[9]

Mechanism of action: Three synergistic processes

Silver diamine fluoride's clinical efficacy derives from three synergistic mechanisms of action, first systematized by Shimizu and Kawagoe in their 1976 investigation[2,15,16] and subsequently expanded through recent mechanistic research.[9,10,17] These mechanisms work together to arrest deep lesions while preserving pulp vitality.

Mechanism 1: Obturation (sealing) of dentinal tubules

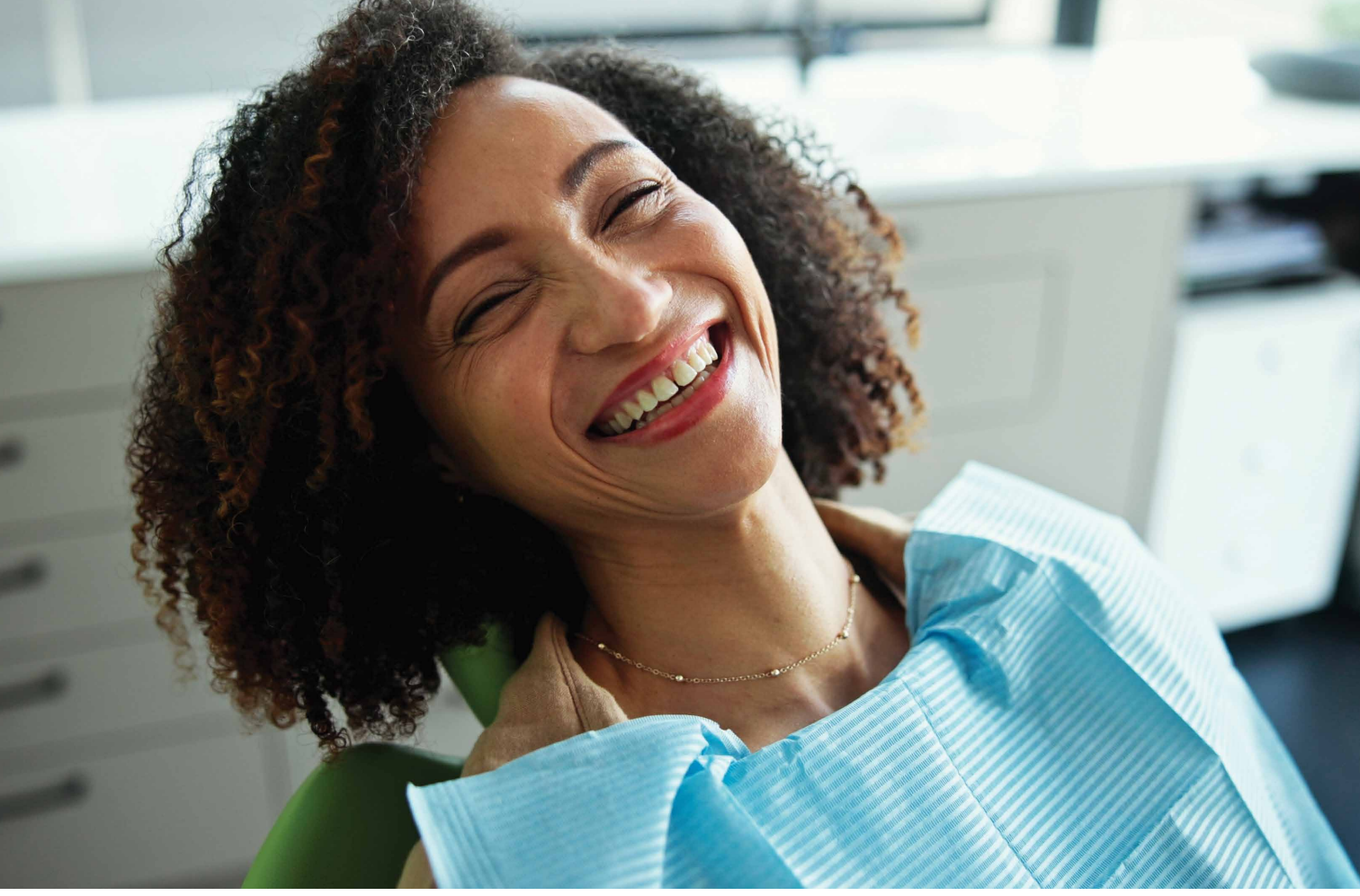
When SDF contacts demineralized dentin, silver compounds form and deposit within the dentinal tubules, sealing them closed.[9,10] These deposits create a protective barrier that blocks cariogenic bacteria pathways and increases resistance to acid attacks.[10,17] In deep caries, this bacteriologic seal prevents further bacterial invasion of the pulp chamber while allowing the pulp to mount a defensive response, significantly reducing vulnerability to recurrent caries and pulpal involvement.[2]

Mechanism 2: Remineralization and strengthening

Fluoride from SDF diffuses into dentin, reacting with hydroxyapatite to form calcium fluoride that converts to fluorapatite, which is more resistant to acid attacks.[9,10,17–19] The calcium fluoride serves as a fluoride reservoir, releasing ions to promote additional fluorapatite formation when oral pH exceeds 5.5.[2,9] Laboratory studies show SDF significantly hardens dentin surfaces, preserves collagen from enzymatic degradation, and reduces calcium dissolution, maintaining structural integrity critical for preserving the vitality of the pulp.[2,17,20,21]

Mechanism 3: Antimicrobial action

Silver ions display potent bactericidal activity through multiple pathways: disrupting bacterial cell integrity, targeting DNA, and inhibiting specific bacterial enzymes, notably S. mutans glucosyltransferase.[2,9,10,17,22,23] Recent evidence demonstrates a "zombie effect" wherein silver-killed bacteria retain antimicrobial effects against living bacteria, extending SDF's biofilm suppression activity beyond immediate application.[9,24]



Deep caries management in adults: Prevention of endodontic treatment

Clinical significance of deep caries in adults

Deep caries extending into the pulpal third of dentin represents one of the most challenging clinical scenarios in adult dentistry. Historically, clinicians faced a difficult choice: complete caries excavation with risk of pulp exposure and consequent endodontic treatment or leave carious dentin beneath restorations with risk of continued progression and eventual pulpal necrosis. SDF offers a third option, arrest of deep lesions while preserving pulp vitality and avoiding the need for irreversible endodontic therapy.

Evidence for pulp preservation in adult deep caries

In a recent publication, nineteen studies were identified demonstrating that SDF achieves high caries arrest rates in deep lesions, with outcomes comparable to conventional indirect pulp capping materials and radiographic evidence of tertiary dentin formation, indicating successful pulpal defenses and healing responses.[3] A 12-month randomized controlled trial comparing SDF to mineral trioxide aggregate (MTA), the gold standard for indirect pulp capping, found SDF equally effective in maintaining pulp vitality in permanent molars with deep caries.[25] This finding is particularly significant, as it establishes SDF as a viable alternative to more expensive materials, offering antimicrobial action and ease of application.

The most compelling evidence comes from a retrospective case series of 277 adult teeth (patients aged 26–90 years, with an average age of 64 years) treated with SDF for deep caries. This study reported that 95% of teeth did not require endodontic intervention over follow-up periods ranging from 16 months to six years, demonstrating SDF's substantial pulp preservation capability.[3] This finding carries profound clinical implications, showing that SDF can forestall or eliminate the need for irreversible endodontic treatment in the vast majority of adult cases with deep carious involvement.

A recent two-year cohort study in older adults demonstrated that repeated SDF applications significantly extended tooth survival and reduced the need for restoration or extraction, with patients receiving multiple applications experiencing 9.6 times longer survival compared to single treatments.[4] SDF was more effective than sodium fluoride or chlorhexidine varnish in arresting root caries and preventing new lesions. A 2024 systematic review analyzing randomized controlled trials in adults found SDF caries arrest rates ranging from 25% to 99%, with SDF outperforming alternative materials on both tooth and surface levels—particularly relevant

Histological examination reveals the consistent formation of tertiary dentin across studies demonstrating the material's capacity to stimulate protective processes within the pulp without triggering adverse inflammatory responses when a protective dentinal barrier remains intact.

for the growing population of adults and seniors with root or deep lesions.[26]

Histological evidence of pulpal response

Research has documented the histological response of pulps beneath SDF-treated deep lesions. Histological examination reveals the consistent formation of tertiary dentin across studies demonstrating the material's capacity to stimulate protective processes within the pulp without triggering adverse inflammatory responses when a protective dentinal barrier remains intact.[3]

Critical safety consideration

Research has unequivocally demonstrated that direct contact of SDF with exposed pulp tissue results in severe inflammatory responses, including suppurative inflammation, hemorrhage, and eventual pulpal necrosis, even at dilute concentrations.[3] As a result, SDF application is strictly contraindicated in cases of pulp exposure or suspected pulpal involvement. Clinical assessment must confirm that protective dentin remains between the lesion and pulp chamber prior to SDF application.

Safety Profile in Adult Populations

Staining considerations

The most widely recognized limitation of SDF remains the black staining of carious tooth structure. This occurs through precipitation of metallic silver and silver chloride on demineralized, infected dentin.[2,3,9] Importantly, healthy enamel and sound dentin do not stain black; only porous, demineralized, infected tissue darkens following SDF application. For deep lesions that will receive restorations, staining is not a clinical concern, as the affected tissue will be covered.

Systemic safety in adults

The safety profile of SDF when applied topically to tooth surfaces is excellent. Clinical trials involving over 3,800 participants across 80 years of cumulative use have reported no serious adverse events.[2,9] If SDF contacts soft tissue, temporary gingival whiteness or mild redness may occur, but resolves without intervention.[2,9]

Dosage calculations demonstrate substantial safety margins: one 25 µL drop contains approximately 9.5 mg SDF and can treat up to five teeth.[2] The EPA's lifetime exposure limit for silver is 1 gram total, meaning 1,266 SDF treatments would be required to theoretically reach lifetime exposure limits.[2]

Fluoride safety in adults

While the fluoride concentration in SDF (44,800 ppm) appears high numerically, the actual volume applied is minimal compared to other topical fluorides. One 25 µL drop of SDF contains approximately 2.24 mg fluoride, whereas a typical 5% sodium fluoride varnish unit dose contains 5.65-11.3 mg fluoride.[27]

Clinical contraindications in adults

SDF use is absolutely contraindicated in several clinical situations:

- Pulp exposure or suspected pulpal involvement
- Signs or symptoms of irreversible pulpitis
- Dental abscess or fistula
- Radiographic evidence of periradicular pathology
- Known allergies to silver, fluoride, or ammonia
- Ulcerated or severely inflamed soft tissues in the treatment area

Relative contraindications that require clinical judgment include:

- Patients undergoing thyroid

therapy or taking thyroid medications

- Pregnancy or lactation (insufficient long-term safety data; avoidance recommended per manufacturer guidelines)
- Advanced renal disease (altered fluoride metabolism)

Clinical significance for adult caries management and endodontic prevention

The emergence of SDF and its recognition as an essential treatment option in adult caries management has transformed clinical practice by providing a cost-effective, minimally invasive option averaging $1 per application versus $1,000 or more for restorations and $800–$1,500 for root canal therapy.[2,9]

For older or medically complex adults, repeated SDF use prolongs tooth survival, reduces dental interventions, and is especially valuable for those with limited mobility or living in long-term care facilities.[4] Its proven effectiveness across diverse adult populations and care settings establishes SDF as a foundation of modern caries management, helping to reduce disparities and support retention of natural teeth.[2,4,26]

Conclusion

Silver diamine fluoride has evolved into a globally-recognized, evidence-based therapy offering adult patients with deep caries a compelling alternative to endodontic treatment. The robust scientific foundation, grounded in over 80 years of research and recent clinical evidence demonstrating 95% pulp preservation and nine-fold improvement in tooth survival with repeated applications, represents a paradigm shift toward tissue preservation and minimally invasive intervention.[2,4] Continued product innovation, including Centrix's SilverSense SDF, reflects market commitment to clinical flexibility and broader patient access.

For clinicians focused on patient-centered, minimally invasive care, SDF is critical for preserving natural tooth structure and pulp vitality in adult patients with deep caries. By preventing most endodontic procedures, SDF helps patients maintain their natural teeth and avoid the substantial costs and burdens of root canal therapy, delivering special value in underserved and medically complex populations. **DT**

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