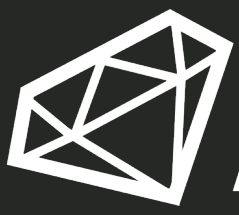


ARM-ER

SILVER FLUORIDE AS AN ADJUNCT CARIES CONTROL, AND THE USE OF S.M.A.R.T TREATMENTS

CATHY BOYCE

SILVER FLUORIDE MODIFIED ATRAUMATIC RESTORATIVE TECHNIQUE

This document is the introduction to and detailed explanation of the following information

- Silver Fluoride;
- Silver Diamine (Diammine) Fluoride;
- Use history;
- Effective action of the product;
- Current protocols for use including:
    - caries detection;
    - caries arrest;
    - prevention capabilities;
    - dentine desensitising; and
    - use within a CAMBRA approach (caries management by risk assessment).
- Safety;
- Side effects;
- Use under a restoration – SMART treatment;
- Expected outcomes; and
- Application and cautions.

HISTORIC OVERVIEW

Silver and fluoride have been used around the world as caries controls agents for centuries. The ‘father of modern’ dentistry, G.V. Black, was aware of the benefits of silver nitrate in the 1800’s and was using it as a part of his dental armamentarium.

Silver diamine Fluoride (SDF) was introduced in the 1960’s in Japan. Adding ammonia to the silver fluoride compound (which made it silver diamine fluoride- SDF) acted as a stabiliser when some early compounds were rendered unstable and crystallised quickly, resulting in a very short shelf life.
In the 1980’s silver fluorides were used extensively in Japan, Australia, Brazil, Argentina, Cuba and China and in many of these countries well before that time.

The use of silver fluoride in Australia was introduced in the late 1970s by Dr. Graham Craig. It was a water based ammonia free composition and was often used in conjunction with a stannous fluoride paste in open lesions in primary molars as an initial treatment for needle-phobic and apprehensive child dental patients. The only other options were to use pre-medication or general anaesthetic. The sales of silver fluoride declined particularly in the 1990’s following the death of the manufacturer who left no succession plan in place.

In 2015 Southern Dental Industries introduced a product known as Riva Star. It contains silver diamine fluoride (35-40%s silver w/v) and a saturated solution of potassium iodide in individual single-use capsules. It was originally developed by Dr. Graham Craig who gave the formulation to Dr. Geoffrey Knight for his Ph.D. research. It was subsequently taken out as an application patent by Drs Craig, Knight and Ngo. This was produced primarily as a cavity cleanser and desensitising agent for minimal invasive dentistry and although not marketed as a caries control agent, the research that was done with the product supported the evidence experienced decades earlier.

About the same time the USA, for the first time in history, also had SDF product approved for use. At 38% SDF it was also approved by the FDA as a desensitising agent for exposed dentine. Since then it has been researched, trialed and used for its caries arresting and remineralising properties.

The company which first produced Silver Fluoride in Australia, Creighton Pharmaceuticals, has been re-established as Creighton Dental. After a period of almost 30 years the former water-based 40% silver fluoride, along with its partner product a 10% stannous fluoride liquid, has reached the market once again as CSDS (Caries Status Detection Solution).

NOTE - *For the purpose of this use protocol paper silver fluoride will be referred to as its correct periodic title of AgF; Stannous Fluoride as SnF2; Potassium Iodide as KI and Silver Diamine Fluoride as SDF. This paper will primarily focus on the protocol for the use of 40 % AgF/10%SnF2 and the applications which could be considered as adjunct materials in dental treatment in the current era.*

WHAT IS SILVER FLUORIDE?

AgF (and SDF) are colourless liquids which contain silver and fluoride ions in their varying concentrations that, when applied to the tooth surface exhibits an ionic exchange with the enamel or dentine.

When AgF is dissolved in water the silver moiety becomes a positively charged silver ion with an electrostatic charge of +1: the fluoride component becomes a negatively charged fluoride ion with an electrostatic charge of -1. In the same way, SnF2 in water becomes a positively charged stannous ion with an electrostatic charge of +2. Additionally, there are 2 fluoride ions each with an electrostatic charge of -1.

When SnF2 is added after the application of AgF, the stannous ions on SnF2 become stannic ions (Sn2+ SnF4+) by donating electrons to any unreacted silver ions remaining in the lesion. These silver ions become reduced to metallic silver (Ag_o).
The highly electrostatically charged SnF4+ ions have the potential to be cross-linking agents and so ‘consolidate’ the carious mass on the surface of a lesion by reacting with broken down proteins and bacterial cell walls etc.

The silver ions kill bacteria in the lesion and when reduced leave elemental silver (Ago) and the stannous ions now stannic ions (4+) react with the proteins and bacterial cell walls etc. With the phosphate and calcium ions from saliva helping with the reaction within the bacterially rich caries lesion a hard black mass forms.

With this process:

1) caries is arrested,
2) silver ion uptake into the enamel and dentine prevents further bacterial activity.
3) dentinal hypersensitivity is decreased

MECHANISM OF ACTION.

The silver ion is an antimicrobial that denatures all proteins, breaks down cell walls and inhibits DNA replication. It also denatures the proteins that break down the dentine. It has been referred to as the 'wrecking ball' for bacterial control. Fluoride promotes remineralisation, inhibits demineralisation and can inhibit plaque bacteria activity.

With the action of these two elements, AgF prevents bacterial growth. Clinically, even in patients exhibiting less than ideal oral hygiene, after a lesion is treated with AgF there is little to no plaque detected in the lesion on a return visit. The more demineralised a lesion is the greater the silver uptake. AgF penetrates into the dentine and fluoride ions passing through the affected part of the tooth can remineralise the dentine below. This undoubtedly makes the dentine more resistant to acid attack through this form of remineralisation process. As with a fluoride ionic exchange, the silver is released very slowly over time and re-application may be required for long term sustainability on an open lesion.

CARIES ARRESTING PROPERTIES.

The application of AgF/SnF2 as a means of caries detection will render the affected caries black in colour. This positive sign indicates that the caries can be treatment planned accordingly. If there is no stain, the result for active caries process is negative.
If after a single application the tooth exhibits a light brown colour, the tooth is not arrested and a repeat application should be made.

Directly establishing the presence and extent of disease and treating the caries process with AgF and SnF or SDF before treatment allows for the arrest of the caries process and the desensitisation of the tooth prior to conventional or intermediate treatment protocols; thus gaining a second form of protection.

As previously explained, research has show that the salivary flow is an important continuation of remineralisation of arrested caries via the fluoride, calcium and phosphate availability. Hence children, with their free-flowing saliva, tend to attain a remineralised (arrested) status longer than the medically compromised, xerostomic adult patient who will benefit from regular reapplications of the AgF to maintain the AgF load in the enamel/ dentine.

There is no evidence of any difference in the arresting of caries in the teeth of children who have not had any of the caries excavated. In fact it is recommended that no caries is removed, as the caries actually increases the uptake of the AgF and SnF2 and improves the outcome. While clinical evidence shows that not 100% of all caries is arrested in one application, studies have also shown the ability of AgF to arrest caries in a single application. Furthermore, studies have shown that the ability of SDF to arrest caries in a single application outperforms both fluoride varnish (applied 3-4 x year) and GIC placement over caries in ART form. Research has shown that the higher the concentration of AgF the better, and as a result 40% AgF/10%SnF2 is better than a 25% -38% SDF in this instance. (SDF concentrations vary according to the manufacturer.)

AgF can be used to detect and treat open caries, interproximal caries, root surface caries and will have remineralising effects in all situations. A recent study in the USA specifically measuring outcomes just two weeks after application of SDF to children with ECC

showed dramatic results. 72% of caries was arrested compared with just 5% in the control group.

When using AgF/SnF2 the colour change occurs immediately and the caries status is evident is within 24 hours. Where AgF or SDF is used alone, there may be a period of 1 week before the lesion turns black and meets the arrested status indication of arrested appearance.

NOTE: *Because of the detection and subsequent arrest of caries the application falls under the ADA Code 123 (application of remineralisation or cariostatic agent to a single tooth).*

CARIES PREVENTION.

With reference to the ability of AgF to act as a bio-inhibitor the ongoing prevention of plaque formation and oral health management issues for some patients should be considered.

There have been a number of objective reviews on the effect of SDF on dental caries (for example Rosedblatt er al., 2009; Horst et al., 2016; Contreras et al., 2017). Some of the findings include;

- Treating caries in children with SDF 1-2 x year there is also a prevention of caries in untreated surfaces up to and outside of 2 or 3 years. Similar results in prevention occurred in teeth treated with SDF instead of CR or GIC sealants thereby affording protection for those members who cannot be protected with these prevention strategies.
- With currently accepted methods of dental treatment, 70% of children who undergo GA for dental treatment get a new lesion within 12 months whilst those who have had treatment with SDF the rate drops to just 30%.
- The prevention and arrest of root surface caries in adults followed over a three-year period, SDF application 1x year was determined to be more effective than a fluoride varnish or chlorhexidine varnish applied 4 x year.
- It has been found that there was a 90% arrest of caries when SDF was applied 2 x year, and a 40-80% arrest rate when applied once a year.

CARIES MANAGEMENT BY RISK ASSESSMENT (CAMBRA)

When considering the concept of CAMBRA the use of AgF within an integrated strategy for high risk patients has a positive role to play.
For higher risk patients (bacterial infection, the absence of saliva, poor dietary habits etc) increased frequency of AgF applications is recommended. Often the initial applications reduce immediate risk but then continue to provide ongoing protective factors.

The visual changes (staining and hardness) after use of the AgF as a caries detecting agent also allows the clinician to 'see' the extent of caries, (now arrested and remineralised) and treatment plan the management of the lesion accordingly. This approach is considerably more conservative, safe, minimally invasive, painless and sound.

IS IT SAFE?

Silver – There have been no reports of adverse events from the use of silver fluoride preparations in the more than 60 years since it was introduced as a caries control technique. The only contraindications are a silver allergy (rare, and not to be confused with an allergy to nickel alloy which is often attributed to silver jewellery 'allergy'), and the presence of desquamative processes in the oral soft tissues (e.g. ulcerative gingival stomatitis, etc).

Fluoride – AgF contains 6% F- ions in a water based solution. This is approximatly twice the concentration of fluoride found in the fluoride varnishes which are commonly used as a remineralising agent (fluoride treatment) throughout the mouth. The use of very small amounts of AgF and SnF2 (2.4%F- ions) in this type of application has no known risk at this level of site specific acute exposure.

If treating a child less than 10kg in weight, restricting the application to 4 teeth at each visit is recommended. This still provides a 500-fold safety margin. For reference, the average 18mth old child weighs approximately 15kg.

SIDE EFFECTS.

Active caries will turn black.

Should SDF contaminate the oral mucosa, small white painless mucosal lesions may appear but will disappear within 48 hrs. An unpleasant taste may remain but can be masked with fluoride varnish of toothpaste etc.

Margins of existing composite restorations will stain if application is applied due to micro leakage. E.g., if applied to root surface caries. Staining of clinical surfaces and clothing can be a problem.

Stains on hard surfaces can usually be removed by applying a sodium hypochlorite domestic bleach (e.g. White King), covering it with a paper towel and leaving it overnight. Stains in clothing can invariably be removed by soaking overnight in a product such as Napisan. Skin staining is temporary but can be removed by the gentle application of a povidone iodine preparation (Betadine).

INDICATIONS FOR USE.

Include but are not limited to:

- Determining the presence, extent and activity of caries.
- As part of CAMBRA in high risk individuals
- Where behaviour or medical management challenges exist
- Where there are more lesions than are treatable at one visit
- As a pre-treatment prior to ART treatment (SMART treatment)
- In difficult to treat lesions (e.g. margins of existing lesions, root surface or furcation caries)
- In patients without immediate access to care.
- Remineralisation of interproximal areas of decalcification detected by bite wing radiographs.

COST EFFECTIVENESS.

CSDS is under $1.40 per treatment (drop) and includes the AgF/SnF2 treatment.
One drop can treat 5 plus lesions. Available in 3ml bottles.

SDF in Australia marketed as Riva Star is available in a single dose application system.

USE UNDER A RESTORATION.

When choosing to place a restoration over a surface that has been treated with silver fluoride product, GIC is preferable for both the sustained fluoride release properties and seal.
AgF does not affect the bond strength of GIC when applied directly prior to placement if after the 3-minute application the area is washed thoroughly. This is also the case when AgF/SnF2 has been used as a pre-treatment 7 or more days earlier. There is evidence that bond strength actually increases due to the very solid arrested and remineralised surface that remains.

Pre-treated caries lesions can be cleaned lightly with a slow speed handpiece to remove the 'crust' of arrested caries and a high-speed handpiece used to reshape the prep and remove some of the stained margins if appropriate. For the greater majority of patients this is pleasingly totally pain free. The tooth can then be treated using the normal protocol of cavity cleanser, and application of GIC. (SMART)
Using an opaque GIC helps with any residual colour showing through from the arrested caries but this is purely from an aesthetics point of view.

If done as a same day procedure the GIC will darken over time and 'activates' substantially if light cured. There is substantially less (usually none) discolouration if placed at a separate visit. Each clinician will determine what is best for the particular case; however, it is advisable to use a self-curing GIC protected with a waterproofing sealer like vaseline to minimise discolouration. Should discolouration or a 'halo effect' around the margins occur, it does not reduce the effectiveness of the material or the treatment.

Silver fluorides can be used under a composite also with no effect on bonding but without the benefit of sustained fluoride release gained with GIC materials.
Do not treat a lesion with AgF to for caries arrest and then place an IRM or Zinc Oxide Eugenol type of material as a temporary filling if trying to arrest the caries. This this will inhibit the formation of the hard black callus desired for arrested caries and the tooth may continue the caries process.

PATIENT ACCEPTANCE.

When the benefits of the use of AgF treatments have been explained to the patients and parents, allowing a sound but much less invasive treatment option for the child, the acceptance rate is extremely high.

Parents should have the concept of the AgF, AgF/SNF2 or SMART treatment carefully explained and given visuals (photographic examples) to allow them to fully understand the steps in the process of the technique and the expected outcome.
The use of an intra oral camera to show them the extent of the caries in their own children is always of benefit to both the parents and children if this is available.
Using positive terms like ‘black diamonds’ is beneficial when referring to the treatment of caries.

Patients and their parents should be fully informed of the possibility that some practitioners may not be familiar with the ‘black diamond’ concept and mistake it for further or recurrent caries and that they should always inform new practitioners of the existence of teeth treated with this mode of treatment.

USE PROTOCOL.

- PPE for patients and clinicians
- Plastic lined tray cover / liners for all surfaces involved in treatment.
- If possible a bristle brush prophy can be used to remove plaque on lesions but this is not necessary for success. (Tapered prophy brushes are ideal)
- Cotton roll isolation, air drying if possible or very thorough drying with gauze
- The use of Garmers Cotton Roll Holders for lower quadrants is strongly recommended
- Optional vaseline protection to gingiva or lips (esp for anterior teeth or root surface caries)
- Dispense the smallest amount possible into a dappen dish
- Apply AgF with a site appropriate micro brush/sponge
- 1-3 min application is appropriate.
- Soak up excess with a small cotton pellet (wash well only if applying GIC directly)
- Apply a small amount of SnF2 with a tiny micro brush to 'activate' the AgF.
- Soak up any excess with a cotton pellet
- Place a protection of 'holding' material over the area - fluoride varnish, MI Varnish, Orabase Protective Paste or petroleum jelly etc,
- Dispose of all materials in a plastic bag as any residual material will permanently stain whatever it comes into contact with. Gingiva or unaffected enamel will only stain temporarily.

Ideally reapply to open lesions 2 x year for caries arrest and continue for 2 years however there will be a substantial gain to caries detection and arrest following the initial application.

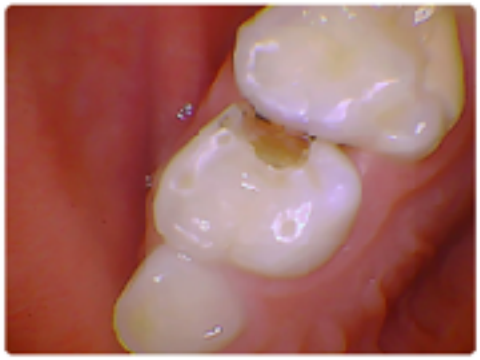
If using Riva Star the lesion is treated in the same way but the use of KI instead of SnF2 is applied following the SDF according to the directions for this particular product.

EXPECTED OUTCOMES.

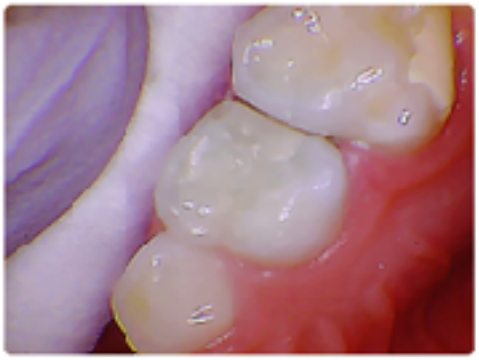
- Caries detection and arrest,
- Remineralisation, desensitisation
- Direct and indirect bacterial control
- Immediate improvement of oral status
- Less invasive treatment
- Patient acceptability because of ease of treatment
- Improvement in quality of care
- Decrease in demand for GA sessions
- Cost efficiency
- Works towards meeting the goals of the Australia's National Oral Health Plan 2014-2025

Carious lesion, pre-treatment.

Silver fluoride applied – black diamonds!



Cavity margins prepared atraumatically.



GIC restoration placed.

ACKNOWLEDGEMENTS.

In preparation of this protocol gratitude is given to the following advisors who have generously shared information in both written and oral forms:

- Dr Graham Craig AM MDS PhD, FRACDS
- Dr Jeremy Horst DDS, MS, PhD (UCSF)
- Dr Silvano D'Ambrosio (Creighton Dental)
- Dr Steve Duffin DDS MBA
- Dr John Frachella DMD
- Dr Jeanette Maclean DDS
- Dr Jason Hirsch MS, DDS