Preventing and reversing peri-bracket white spot lesions
Laurence J. Walsh
BDSc, PhD, DDS, FFO, FRCPA, GCEd, FICD, FADI, FIADFE

Acknowledgements

- Prof Eric Reynolds and CRC OHS collaborators Profs David Manton and Stuart Dashper
- Prof Kim Seow and UQ Centre for Paediatric Dentistry
- UQ academic clinicians and collaborators
- Research students: Lei Chai, Hui Sing Chang, Jason Yap, Carol Tran, Kathryn Plonka, Margaret Pukallus, Teresa Huynh, Annetta Tsang, Jasyn Randall, Sepehr Tabatabee, Alana Evans

• Funding:
  – CRC Oral Health
  – NHMRC
  – Qld Health
  – ADRF

Disclosure 1:
Interactions with GC Australasia

• Saliva Check Buffer kit
• Plaque Check + pH kit (single site caries diagnostic)
• Tri-Plaque ID gel (multisite caries diagnostic)
• G-Coat Plus surface sealant
• Fluorescence imaging camera
• X-ray contrast paste for proximal caries
• Clinical protocols for using Tooth Mousse

Disclosure 2:

• KOL, consultant and adviser to
  – Colgate (oral health consumer products)
  – Oral-B (powered brushes)
  – Johnson & Johnson (mouthrinses)

Decalcification during orthodontic treatment

• Common complication of fixed orthodontic treatment
• Reported prevalence up to 96%
• The teeth most commonly affected are MD molars, MX lateral incisors, MD premolars
• Limited contact with saliva


Online resources: Recaldent

• http://www.gcasia.info/download-australia.asp
• White spots book
• Tooth Mousse Cookbook
• A World of Proof
• Usage guide
• Nothing else comes close
**Tooth surface protection options**

- **Short term effect (days – thus need to repeat)**
  - F varnish (various brands)
  - CPP-ACP varnish (GC MI Varnish)

- **Surface coverage (years)**
  - Unfilled resin (e.g. sealant)
  - Filled resin (micro or nanofillers)
  - GIC with high F release (Fuji VII)
  - GIC with CPP-ACP (Fuji VII EP)

**Orthodontic labial protective veneer material placed around brackets at the time of bonding**

- Aesthetic (Translucent or tooth shaded)
- Resists brushing
- Paint on application – thin layer
- Easy/practical to remove

- Yap et al. ADJ 2014
Smooth Surface Sealant (SSS)

- “Enamel sealant”
- Transparent
- Low wear rate from toothbrushing

Silverstone 1974

Smooth Surface Sealant (SSS) adjacent to orthodontic bracket

G-COAT PLUS gives superior wear resistance and gloss retention

- GC G Coat Plus
- The only light-cured, protective clear coating formulated with adhesive monomer and evenly dispersed nanofillers. One thin coat protects the surface and fills in scratches and small voids.
- MMA containing

GIC for Tooth surface protection

CURRENT:
- GC Fuji VII for partially erupted teeth
- GC Fuji VII EP (containing 10% Recaldent CPP-ACP), e.g. to protect exposed roots

Both have high F release and F recharging (market leading)

Fuji VII / Triage (and EP)
Buffering lactic acid from dental plaque fermentation

- GIC have an ability to buffer lactic acid.
- Lactic acid at the pH of active caries (4.5) can be buffered to the pH of arrested caries (5.5) within less than 30 seconds, and with negligible erosion of the GIC.
- This effect is likely to be beneficial, and would inhibit the development of caries around a GIC.


Hypothesis

- GIC with CPP-ACP smooth surface sealant provides superior protection than resins against enamel demineralisation adjacent to orthodontic brackets due to the combined physical and chemical protective effects.

Materials

- Resin fissure sealant (Conseal Clear)
- Nano-filled self-adhesive (G-Coat Plus)
- Resin infiltrant (Icon)
- Autocure GIC containing CPP-ACP (FUJI VII EP)

Quantitative Light-induced Fluorescence (QLF)

- QLF has been shown in laboratory studies to be a useful technique that may be applied to orthodontic patients. It has been validated against several other methods of quantifying demineralization. (Aljehani 2004, Shi 2001)
- QLF can be used in both laboratory and clinical settings.
Backscatter SEM analysis (lesion depth)

 Fuji VII EP releases CPP-ACP to discourage biofilm growth

<table>
<thead>
<tr>
<th>5. S. mutans biofilm formation after 16 hours inoculation at 37ºC with Fuji VII GIC as the substratum.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. S. mutans biofilm formation after 16 hours inoculation at 37ºC with Fuji VII EP containing 3% Recaldent™ as the substratum.</td>
</tr>
</tbody>
</table>

A/Prof S Dashper, CRC Oral Health

Fujii VII EP Surface sealant for inhibiting enamel demineralisation.


Future purpose-built materials for peri-bracket protection

- Tooth-coloured GIC with CPP-ACP
- Tooth-coloured GIC with CHX release
- CPP-ACFP varnish (applied in multiples)
- Smart resin
  - Avoid TEGDMA and EDGMA

<table>
<thead>
<tr>
<th>Table 1: Biological effects of nanocomposites and degradation by-products of conventional resin composites.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
</tr>
<tr>
<td>Kato, Y. 2002 [16]</td>
</tr>
<tr>
<td>Rossi, S. 2008 [18]</td>
</tr>
</tbody>
</table>

Resin components with advantages

- Avoid TEGDMA and EDGMA
Protocol: MI varnish (CPP-ACP/F) versus Duraphat varnish (F) for preventing enamel demineralization around bonded brackets, assessed using Optical Coherence Tomography

Results: "MI varnish was shown to be more effective in diminishing caries lesion depth compared with Duraphat, irrespective of brushing and F mouthwash use."

Background: Glass ionomer cements (GICs) are a class of dental biomaterials. They have a wide range of uses including permanent restorations, filling cavities, fissure sealants and adhesives. One of the most common reasons for replacing a dental restoration is recurrent bacterial tooth decay. The aim is to create GICs which contain chlorhexidine-hexametaphosphate nanoparticles and characterize the nanoparticle size, morphology and charge and the release of chlorhexidine and fluoride, tensile strength and morphology of the GICs.

Results: The GICs released chlorhexidine, which is a broad spectrum antimicrobial agent effective against a wide range of oral bacteria, over the duration of the experiment in a dose-dependent manner. This was not at the expense of other properties. Vicker’s hardness was significantly affected by the substitution of antimicrobial nanoparticles in most formulations and internal moisture appeared unaffected up to and including 10% substitution. Diametral tensile strength decreased numerically with substitutions of 10 and 20% nanoparticles but the difference was not statistically significant.

Conclusion: A series of GICs functionalized with chlorhexidine-hexametaphosphate nanoparticles were created for the first time. These released chlorhexidine in a dose-dependent manner. These materials may find application in the development of a new generation of antimicrobial dental composite materials.

Competing interests
The University of Bristol filed a patent application relating to the work presented in this manuscript in 2013.

“Photonic conversion”

- Light-activated fluoride (LAF) therapy using neutral NaF gel or APF then 20 seconds/tooth light 15 J/cm²
- Previously shown with 488 nm blue laser
- Works across visible and NIR wavelengths to protect dental enamel from cariogenic challenges (488, 532, 633, 760, 830, 1064 nm). Works with LEDs or lasers.
- Surface conversion to FAp. Increased Vicker’s hardness. Increased resistance of enamel to acid dissolution in laboratory models of dental caries.

Release of CHX

Release of Fluoride

Figure 1. Cumulative CHX release from experimental GIC specimens with varying substitutions of CHX-HMP nanoparticles.

Figure 2. Cumulative fluoride release from experimental GIC specimens with varying substitutions of CHX-HMP nanoparticles.

Less cariogenic plaque

- Reduce plaque biomass and maturity – regular mechanical disruption by brushing/interdental cleaning: Use toothpaste - Effect of toothpastes on cariogenic bacteria (more on this in Lecture 2)
- Lower plaque acid production – less dietary substrate, lower levels of aciduric and acidogenic species
- Alter plaque ecology – using CHX or CPP-ACP/ACFP
Black cola drinks, oral health and general health:
AN EVIDENCE-BASED APPROACH

Coca Cola and ACCC

• Reduce frequency of sucrose and other substrates between meals
• Replace substrates with non-cariogenic alternatives
• Twice daily brushing with fluoride toothpaste
  » 5000 ppm if high risk
• Interdental cleaning
  » Floss
  » Interdental brushes
  » Philips AirFloss
Non-cariogenic food sweetener replacements:
- ISOMALT
- SUCRALOSE (Splenda)
- STEVIA
- SORBITOL
- XYLITOL

- Direct bactericidal effect on \( S\) \( mutans \) and \( S\) \( sobrinus \)
- Reduced adherence to substrates (teeth)
- Inhibition of GTF (thus less sticky glucans)
- Inhibition of salivary and bacterial amylases

Epigallocatechin gallate (EGCG) is an antioxidant and antimicrobial component of tea catechins.
- Minimum bactericidal concentration 62.5 \( \mu \)g/mL.
- Interferes with attachment of \( S\) \( mutans \) by suppressing \( gtf \) gene expression associated with biofilm formation and cell adherence
- Acts at sublethal doses.
- Natural anticariogenic compound that could lower biofilm level without having to suppress the growth of the oral bacterial population.


![Graph showing suppressed attachment of Sm](image)

Fig. 3 – Effect of sub-MIC levels of EGCG on \( gtfB \), \( C \), \( D \) genes expression of \( S\) \( mutans \) UA159 grown in chemically defined medium. *Significant inhibition was observed compared with non-treated control.
Ecological therapy with CPP-ACP

- Lower adherence of key pathogens to tooth surfaces, pellicle and existing biofilms, e.g. by blocking adhesins
- Elevate plaque fluid pH by buffering plaque acids (protein and phosphate)
- Decreased fermentation from bio-available Ca and fluoride ions
- Large bio-available calcium ion reservoir slows diffusion of free calcium.

---

Inhibition of mutans streptococci and plaque by CPP-ACP


Tooth Mousse Results: MS

- TM eliminates high MS levels in dental plaque in 2 year old children.
- Using TM one child with one carious tooth.
- MS presence reduced P = 0.02 
- 90% of TM 1+ group had zero presence of MS, with none >10^5

Tooth Mousse Results: LB

- TM no effect on LB levels

Effects of CPP-ACP on biofilms

- Effect of 2% CPP-ACP spray against Cariogenic & Non-Cariogenic Bacteria
  - High MS subjects
    - 2% w/v CPP-ACP in deionized water (pH 7.0) with 0.5% benzylate preservative and 0.1% mint flavouring, vs placebo
    - 2x 0.1 mL sprays twice per day, 2 weeks
    - Reduced MS count in plaque
    - From 14 High MS to 2 High MS + 2 Low MS
    - Lesser effect in reducing the LB count
Before and after TMP for 4 weeks

S. mutans biofilm testing using the flow cell model

• S. mutans incubated for one hour to encourage cell attachment formation
• 25% ASM was pumped through the system at 0.2 mL/min over 15 h (total running time = 16 h).
• Biofilm in the flow cell stained with Live/Dead® BacLight™
• Biofilms imaged using Confocal Laser Scanning Microscopy.
• Images analysed using the COMSTAT software.

Confocal Microscopy

• S. mutans incubated for one hour to encourage cell attachment formation
• 25% ASM was pumped through the system at 0.2 mL/min over 15 h (total running time = 16 h).
• Biofilm in the flow cell stained with Live/Dead® BacLight™
• Biofilms imaged using Confocal Laser Scanning Microscopy.
• Images analysed using the COMSTAT software.

Antimicrobial effect of CPP-ACP

1% CPP ACP treated
Treated with 1 mL 1% CPP-ACP for 10 min

Control
Treated with 1 mL water for 10 min

A/Prof S Dashper, CRC Oral Health

Clinical Guidelines for Application of GC Tooth Mousse and GC Tooth Mousse Plus

The following results can be drawn from this randomized controlled trial.
1. MI Paste Plus not only had a preventive action of white spot development during orthodontic treatment, but also decreased the number of white spot lesions.
2. The placebo had no preventive action on white spot development during orthodontic treatment; the number of lesions actually increased.
3. MI Paste Plus had an impact on reducing white spots on the gingival surfaces, whereas the placebo group had the opposite effect.
Orthodontic WSL Reversal: Clinical aspects

Map the full extent of white spots

- Clean and dry the tooth
  - Visual inspection of the dry tooth with magnification
- Fluorescence using orange filter

Active white spot caries: porous surface

Active WSL

- Active white-spot lesions on the buccal surfaces = dull, rough and chalky white in a plaque stagnation area with adjacent mild gingivitis.
- Zandona & Zero, 2006

Arrested WSL

- Arrested WSL = shiny, smooth, translucent and having healthy adjacent gingiva.
• Arrested WSL = shiny, smooth, translucent and having healthy adjacent gingiva.

Prof. Edwina Kidd
J Dent Res. 2004; 83 Spec Iss C: C35-38

• Active enamel lesions involve surface erosion and subsurface porosity.
• Inactive or arrested lesions have an abraded surface, but subsurface mineral loss remains, and a true subsurface remineralization is rarely achievable, because the surface zone acts as a diffusion barrier.

Requirements for remin

• Diffuse into the subsurface
• Overcome the challenge of delivery Ca and P into the subsurface zone
• Not delivery an excess of Ca
• Work at lower pH than neutral range

DT Zero, BMC Oral Health 2006;6(Suppl 1)

First report of post-orthodontic WSL reversal using Tooth Mousse (Walsh 2004)

Key issue: ensuring surface penetration for arrested lesions!

Various methods for this:

Short acid etch
Peroxide
Proteolytic agent (Tran et al. 2013)

No need to etch ACTIVE lesions prior to CPP-ACP as their surface is porous

Need to surface treat arrested lesions to make the surface permeable
Clinical protocol for treating ‘active’ white spot lesions

1. Clean teeth thoroughly using a soft brush and low-medium concentration fluoride tooth paste
2. Immediately follow with an application of GC Tooth Mousse Plus, either directly to the surface. Alternatively load into the patient’s orthodontic retainer in the region of the white spot lesions.
3. Repeat twice daily.
4. Continue the treatment until the tube of Tooth Mousse Plus is finished.
**Don’t use in trays** – less saliva contact!

No surface treatment was done of the lesions. Key factor!!

Intervention was delayed so some natural arrest of WSL would have occurred.

Duration of Tx only 8 weeks – too short

Digital analysis not corrected for reflections (or polarizing effects)

---

**Tx of fluorosis after debanding**

- 1. Check for and remove any surface bonding residues after orthodontic treatment
  - Diagnostic etch 10 seconds

- 2. Enamel microabrasion
  - Etch 37% phosphoric acid for 2 min with agitation
  - Gentle abrasion with fine pumice 1500 rpm
  - Repeat (X2) until surface contour is even

- 3. Apply Tooth Mousse Plus
  - Immediately, and then each night before bed
  - Review at 4-6 weeks
What happens if patients apply TMP to their teeth and there are no visible WSL present?

- Alters the plaque (lower MS)
- Alters the outer enamel
- More reflection of short wavelength blue and violet light
- Less yellow appearance

"Tooth lightening" (2008)