Atraumatic Restorative Treatment; Quick Lesion Debridement & Caries Control

Nels Ewoldsen DDS, MSD

(preface: Regardless of patient age, an important early step in managing caries ravaged teeth involves rapid lesion debridement and restoration, protecting the pulp and preventing caries progression. Interim therapeutic restorations (ITRs) in deciduous teeth, as well as sedative fillings in permanent teeth, can be placed quickly and inexpensively using the Atraumatic Restorative Treatment (ART) technique. After more than 20 years of clinical use, ART remains under-utilized in early childhood caries (ECC), adolescent and adult caries management in the US. This article focuses on the evidence-based clinical protocol and material selection for successful ART restorations.)

While millions of Americans have benefitted from caries prevention and management techniques, approximately 20% of the US population has active caries lesions. 1,2 Additionally, a disproportionate percentage of these children, adolescents and adults have multiple untreated caries lesions, or cavities. 2 (Figures 1, 2) Without restorative intervention, nearly all cavitated caries lesions will advance to acute caries threatening pulp vitality and patient health. Patients with multiple cavitated lesions presenting for dental treatment are often confronted with restorative treatment costs beyond what they can afford. Prioritizing lesions and addressing the most serious problems first helps somewhat but that approach delays treatment of some active, progressing lesions. In general, deferring restorative care only adds expense and brings new complications. This article reviews Atraumatic Restorative Treatment (ART) with emphasis on ART as a full-mouth debridement caries management technique. Developed for field use in under-served regions, ART offers expeditious affordable restoration of caries lesions in permanent and deciduous teeth.

ART is a minimally invasive approach addressing caries using only hand instruments and placement of an adhesive restoration to remineralize caries affected dentin. ART has been shown to conserve tooth structure and prevent continuing caries in treated teeth. Today’s ART techniques rely on highly viscous, restorative glass ionomer cements (GICs) which also function as fissure sealants. GICs are pulp-friendly, tooth colored, water-based dental cements that bond chemically to tooth structure and exchange ions with their surroundings. 3-7

Pioneered by World Health Organization, ART was introduced as a restorative technique for the estimated one-half of the World’s population living without running water or electricity. Featuring manual hand instruments, these restorations were used initially to restore fissure caries (Class I lesions) in permanent teeth. 4 Caries removal, completed without local anesthetic, required accessing lesions using pyramid shaped enamel hatchets followed by spoon excavators to address lateral spread of caries at the dentinoenamel junction (DEJ). Experienced clinicians listen for a ‘ringing sound’ from the spoon to indicate complete removal of infected dentin. Caries infected dentin is not remineralizable whereas caries affected dentin can be remineralized. Caries affected dentin retains the microstructural characteristics of dentin and is resistant to cutting or removal by hand instruments. Caries infected dentin consists of decomposed tissue with oral debris and is easily removed. Lesion debridement is arguably a better term than cavity preparation when the ART technique is used.

Adequate lesion debridement should produce clean, caries-free cavosurface margins. Removal of unsupported enamel is not required. Carious dentin at the depth of the lesion may be left to avoid exposing the pulp or traumatizing the patient. Laterally, however, removal of caries infected dentin and a sealed cavosurface margin are essential for successful long-term ART restorations. Without rotary...
instrumentation, outline form extension along caries-susceptible fissures is not possible hence most occlusal ART restorations function as fissure sealants at their periphery.\(^8\)

Scientific publications in the mid 1990s validated highly-viscous GICs placed using the ART technique in Class I lesions.\(^4\) A few years later success was reported for ART treatment of smooth surface lesions. The lowest success rates are for Class II lesions in deciduous teeth with slightly better performance of Class II restorations in permanent teeth. The mediocre strength and brittleness of GIC restoratives limit their long-term success in high load areas such as incisal edges and working cusps. However, even in heavy load demand situations, highly viscous GICs have functioned well as intermediate restorations, frequently chipping but rarely showing catastrophic fracture with recurrent caries.\(^8,9\) Esthetic shaded GIC formulations can be used in anterior teeth. Highly viscous GICs are more opaque than composite resins and their polished surfaces resemble macrofill composite rather than today’s smaller particle composites.

Initially GICs for ART consisted of hand-spatulated versions requiring the aluminosilicate glass to be mixed with the polyacid liquid on a glass slab. Fuji IX was one of the first successful highly viscous ART GICs and remains popular today. The sequence for placing ART restorations using Fuji IX begins with wetting for a few seconds the cleaned tooth surfaces with a polyacid saturated cotton wool pellet before having the patient swish and empty. A dry cotton wool pellet is then used to blot up excess moisture while the assistant mixes the cement which is then press-finger placed into the cavity. The setting GIC is isolated from saliva for 1-2 minutes and sculpted as hardening progresses. Capsulated, fast-setting Fuji IX is available today in a variety of shades and is triturated in a mechanical mixer. For those wondering how a restorative GIC became identified as “IX”, the answer is simple: placement of the cement mixture was the ‘ninth step’ of ART. At the time Fuji IX was developed, use in conventional dental settings was not anticipated.

The surprising success of ART restorations in field settings prompted dentists worldwide to request Fuji IX for use in their practices. Recently GC America introduced Equia, the latest version of fast-setting Fuji IX, a capsulated highly-viscous GIC for Class I, II, and V restorations. Although Equia fissure sealants and for Class III restorations constitute “off-label” use, upon obtaining informed consent, such applications are common. Figures 3, 4 show a Class I and Class III Equia (formerly called Fuji IX GP X-tra) restoration completed using a single mix, Shade A2, with acceptable esthetics. Figure 5 shows a fissure sealant at 4 years, placed using an early version of Fuji IX in a dental office setting.

It’s important to remember that GICs are water-based cements, hence they contain water and are tolerant of moisture during placement. During initial hardening and throughout their life, GICs require water to support ion movement and exchange. Ion exchanging, water-based cements bond to calcified tissues via the carboxyl groups of the polyacid. The initially low pH of the mixed cement liberates aluminum, calcium and/or strontium as well as fluoride from the aluminosilicate glass. Calcium and strontium are quickly taken up into decalcified tooth tissues along with fluoride.\(^6\) With time, aluminum replaces calcium and strontium stabilizing the cement matrix resulting in a hardened cement with increased translucency. Since fluoride does not participate in the setting reaction, it remains free to diffuse into surrounding tissues and fluids. Anytime the oral environment becomes super-saturated with fluoride, such as during a topical treatment, fluoride ions diffuse into the water phases of the GIC for subsequent release when salivary levels drop. This has been termed the “fluoride reservoir effect” of GICs.

Longitudinally tracked as well as statistically estimated survival of ART restorations has been reported in several published studies with median survival ranging from two to ten years.\(^5,9\) Survival varies by size, location, class of the restoration and treatment setting. Class I restorations in permanent teeth, treated in a clinic setting show the highest survival followed by Class I permanent tooth restorations placed in a field setting. Class I restorations in deciduous teeth show slightly lower survival compared to permanent teeth.
while Class II restorations in deciduous teeth are nearly as likely to fail as they are to succeed by year two. Generalized, non-weighted results of various reports and reviews of the literature are shown in Table 1.

ART enjoys high patient acceptance primarily due to its simplicity. Reduced instrumentation requirements (Figure 8), possible avoidance of local anesthetic and use of spoon excavators rather than the dental hand piece equate to favorable psychological impact and reduced discomfort. In a policy statement describing interim therapeutic restorations (ITRs) The American Academy of Pediatric Dentistry recognizes the advantages of ART techniques for step-wise caries excavation in children with multiple open carious lesions prior to definitive dental restorations.

Whether ART constitutes provisional or definitive restorations can depend on pulp status, patient cooperation, operator experience with ART debridement techniques as well as size, surfaces and functional demands of the restoration. Figures 7-12 highlight steps for preparing and restoring a Class V lesion using Fuji IX X-tra. Lesion debridement concluded with ringing of the spoon excavator against remineralizable dentin, the cavosurface margins were visibly clean. Polyacid wetting of the cleaned surfaces was completed using GC Cavity Conditioner for 20 seconds before the teeth were rinsed and lightly dried. Capsulated Fuji IX X-tra, Shade A2, was syringed into the preparation. After placement of GIC into tooth #22 a gloved finger lubricated with a small amount of unfilled resin was used to press-finger contour. Following placement and contouring, peripheral excess was removed and unfilled light-cured resin was applied to the restored surface and cured. Coating freshly placed GIC restorations with a protective resin assures optimal hardening and has been shown to increase wear resistance. This restoration as well as the Class I and Class III shown previously were coded as composite resins and billed as definitive fillings to the Illinois Department of Medicaid.

Interim Therapeutic Restorations are billed using the code for ‘sedative filling’, D2940, CDT 2012. Figures 13, 14 illustrate ART for ITRs in a pediatric patient. Caries excavation was completed without local anesthetic and the teeth were conditioned, rinsed, blotted dry before capsulated Fuji IX X-tra was syringe delivered to the teeth then press finger placed to form. Figure 15 shows ITRs one year after placement in a field setting by a senior dental student (Nuevo Ocotepeque, Honduras) using the original formula hand-mixed Fuji IX. The restoration margins are stained but free of caries.

Restorative materials other than GIC have been tested as ART fillings however GIC has outperformed all others. Outcomes obtained using highly-viscous GIC can rival outcomes of conventional restorative procedures especially when patient cooperation is poor and/or caries risk is high. It is important for dentists to be aware of ART as conservative caries debridement technique. The remarkable infrequency of secondary caries associated with ART restorations suggests that GICs are cariostatic and that caries affected dentin can be remineralized. The disproportionate burden of caries in a small but significant percentage of children, adolescents and adults in the US today is a stark reminder that new caries management techniques are needed. Atraumatic Restorative Treatment is a validated patient-friendly caries management technique which conserves tooth structure, preserves pulp health, and controls caries lesions economically and expeditiously. Single-visit, full-mouth caries debridement using ART technique provides dentists and patients an economical, time-saving approach to controlling active caries. The longevity of these restorations buys precious time and conserves resources as their ion exchanging properties harden caries-damaged teeth while restoring esthetics and helping preserve pulp vitality.

References
2. 2. www.cdc.gov/Features/dsUntreatedCavitiesKids Center for Disease Control and Prevention, Untreated Dental Caries (Cavities) in Children Ages 2-19, United States, Feb 9, 2011.
10. American Academy of Pediatric Dentistry, Policy on Interim Therapeutic Restorations (ITR) Oral Health Policies REFERENCE MANUAL.

Table 1: Non-Weighted & Generalized, Restoration Survival Percentages from Clinic & Field Trials

<table>
<thead>
<tr>
<th>Restoration Survival @ 1 year</th>
<th>Deciduous Class I</th>
<th>Deciduous Class II</th>
<th>Deciduous Class V</th>
<th>Permanent Class I</th>
<th>Permanent Class II</th>
<th>Class V &amp; Root</th>
<th>Anterior Multi-surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restoration Survival @ 2+ yrs</td>
<td>95&amp;&lt;br&gt;&amp;70%&lt;br&gt;&amp;87%&lt;br&gt;&amp;86%-98%&lt;br&gt;&amp;85%-97%&lt;br&gt;&amp;87%&lt;br&gt;&amp;No reports found</td>
<td>79&amp;&lt;br&gt;&amp;&lt;20% - &gt; 50%&lt;br&gt;&amp;71%&lt;br&gt;&amp;81%-94%&lt;br&gt;&amp;40%&lt;br&gt;&amp;+50%, 30%, one report</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: Young adult patient after 4 year absence from dental care

Figure 2: Four year old patient presenting for initial dental visit

Figure 3 a, b: Class I lesion cleaned using ART technique (a), to receive GIC, restored (b) with Equia.
Figures 4a,b: Same patient shown Figure 3a,b receiving Class III ART preparation (a) and restoration (b), same capsule mix used for both restorations, Equia, Shade A2.

Figure 5: Tooth #31 Fuji IX sealant 4 years after placement

Figure 6: Atraumatic Restorative Treatment tray set-up including mirror, explorer, spoon excavator, cotton pliers and polyacid tooth conditioner, capsule delivery system with Equia and light-cured resin with 2X2 gauze and microbrush.

Figure 7: Spoon excavator debriding lesion without local anesthetic.
Figure 8: Polyacid conditioner applied to debrided cavity prior to rinsing.

Figure 9: Rinse using air-water syringe and suction prior to placement of GIC.

Figure 10: Equia (GIC) delivered to the cavity.

Figure 11: Nitrile glove fingertip with drop of light-cured resin (Equia Coat) used to press-finger place and contour Equia restorative.
Arresting Caries Treatment (ACT): Products & Techniques

Silverdiamine Fluoride (SDF) solution applied to caries combines antimicrobial and remineralization properties arresting caries but discoloring caries-affected enamel and dentin. Following the application of SDF, potassium iodide (KI) forms a white precipitate reducing or eliminating the staining effects of silver and fluoride incorporated into remineralized enamel and dentin.

SDF (silver capsule) is painted onto spoon-excavated caries lesions for several seconds followed by application KI, forming a white precipitate. Caries affected dentin is rapidly hardened by the crystal precipitates. The silver ion is antimicrobial destroying cariogenic bacteria. GIC is applied to the SDF/KI treated teeth.
A 38% SDF solution applied directly to caries with minimal debridement will ‘arrest caries’ however the remineralized dentin is permanently discolored. Both tooth form and esthetics are compromised; caries are effectively stopped. Use of SDF with and without KI is “off label” in the US as no products for caries arrest have been cleared to market by the Food & Drug Administration.

Both deciduous teeth were restored with GIC and stored in refreshed saliva for 22 months. Remineralization at the margins causes discoloration, the use of SDF followed by KI before placement of GIC restorative results in no marginal discoloration related to remineralization. (photos courtesy Dr. G. Knight)

Fluoride varnish & MI varnish applications have been shown to remineralize intact enamel potentially reversing white spot lesions (WSL) after multiple applications.

WSLs are the optical result of subsurface demineralization which results in water/air filled channels below the enamel surface altering the optical index of refraction.

Remineralizing the subsurface channels, or eliminating the water/air and infusing the voids with resin restores the refractive index reducing WSL opacity. Non-fluoride remineralizing products include MI Paste (GC America) and theobromine, a chocolate extract (Theodent).

Resin infiltration of WSLs (Icon, DMG) requires acid etching followed by rinsing and ethanol drying before applying a low viscosity light-activated resin. Photos from Drs. AM Bancroft and JJ Bancroft [http://www.orthodonticproducts.com/2012/09/resin-infiltration-for-treatment-of-post-orthodontic-white-spots/]

Nels Ewoldsen DDS, MSD  Conservative Dental Solutions, Waveland, IN 47989  newolvoldsen@gmail.com