

## Review Article

# Atraumatic Restorative treatment (ART)

Michel Goldberg\*

Department of Oral Biology, Paris Cité University. - Biomedicale des Saint Pères, France

## \*Corresponding author

Michel Goldberg, Department of Oral Biology, Paris Cité University- Biomedicale des Saint Pères, France, Tel: 331662676709; Email: mgoldod@gmail.com

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## Abstract

ART is a therapy that contributes to heal and prevent the increase of carious diseases. Previous studies have identified two parts in dentin carious lesion, the superficial infected part, and the inner affected portion. In the infected part, bacteria are numerous, located beneath the dentino-enamel junction. The mantle dentin is destroyed, and also peritubular dentin. Intertubular dentin is demineralized, and the decay is diffusing through enlarged tubules filled by bacteria releasing proteases. This soft part of the lesion may be removed manually using excavators. In the deep part, the affected dentin, peritubular dentin reappears gradually. The mineralization of the intertubular dentin is rising up to the level of the sound dentin. Some tubules are occluded by intraluminal mineralized structures, contributing to the formation of a sclerotic zone. Chemo-mechanical strategies aimed to keep the deep part of the lesion, susceptible to be a scaffold for re-mineralization. The sclerotic dentin layer provides a firm surface where dental surgeons are susceptible to glue adhesive biomaterials such as glass ionomers. ART strategies aim to eliminate the soft carious layer and preserve the affected layer which may heal and remineralize. This constitutes the basis for Minimal Intervention Dentistry (MID) and/or Atraumatic Restorative Treatment (ART). ART constitute nowadays a good substitute to the Black's classical cavities. It prevents cariogenic spreading and the increase of carious lesions.

## INTRODUCTION

For years pediatric dentistry and adult therapies involving dental cares have used the classification of cavities developed by [1] This operative and restorative dentistry implicates the preparation of cavities, involving also sound tissue (for the prevention of recurring lesions) and for mechanical reasons. The different classes of cavities were prepared in order to be filled by biomaterials deprived of adhesive properties such as gold aurifications, silver amalgam and phosphate-containing cements. Therefore this implies preparations adapted to mechanical commitments. With the evolution of the properties of more recent biomaterials, the concepts have evolve and the new properties of restorative materials have modify the classical concepts, taking in consideration the adhesive properties, and the physiopathology of carious diseases.

- Prevention has three different levels : **Primary prevention** focuses on preventing new cases of oral diseases. It uses collective prevention measures such as fluoridation of water and/or school oral health programmes. At the individual size, **primary prevention** aims to prevent the early colonisation of childrens' teeth by cariogenic bacteria. Prevention also includes the management of other factors, avoiding cariogenic dietrich in fermentable carbohydrates, aggravated by poor oral hygiene habits.
- **Secondary prevention** aims at preventing the disease

established and progressing. This includes screening to detect carious lesions at the earliest possible stage so that appropriate treatment can be delivered.

- **Tertiary prevention** aims to prevent recurrence of disease as well as the failure of preventive and restorative care initially implemented.

With regards to this evolution, ART, pioneered in the mid 1980's in Tanzania is based on le removal of soft carious dentin using hand instruments alone, keeping intact the partially demineralized carious dentin, and restoring the cavity with an adhesive material namely the glass-ionomer cements (GIC) [2].

## ANATOMOPATHOLOGY OF THE CARIOUS DENTIN

Carious tissue includes two layers. The first outer layer is named **infected dentin**. It contains denatured collagen and numerous bacteria, and in addition food debris. The inner layer is called **affected dentin** and is located under the infected layer [3,4]. Its consistency is harder, the collagen fibrils are not denatured. There is a loss of mineral and the extend of bacteria colonies is reduced. The objective of ART is to remove the infected dentin, and seal the cavity with an adhesive material, promoting an favorable environment for the inner dentin which may remineralize and heal. Adhesive properties of biomaterials play role in this process, and after some time the mineral level return to anormal percentage. It is clear that the spontaneous treatment of the carious lesion implies the preservation of the sclerotic zone, and ions diffusion in the softened carious tissue.

In continuity with the enamel early lesion, the lesion includes microbial invasion (or necrotic zone), crossing the Dentino-Enamel Junction (DEJ), spreading along the DEJ, The active decay erodes the mantle dentin and progress in the deeper dentin layers, until the lesion reaches the pulp.

The **superficial dentin** is altered (soft carious dentin, or decalcified layer), and collagen fibers are partially destroyed by endogenous metalloproteinases (MMP-1, MMP-2, MMP-8, MMP-13, MMP- 14, and MT1-MMP) and bacterial proteases. Enzymes cleave the collagen fibrils into  $\frac{1}{4}$  and  $\frac{3}{4}$  segments. Cathepsin K cut both tooth helical C-and N-terminals, and remove the telopeptides from the collagen fibers. Cysteine cathepsin degrade type I collagen, laminin, fibronectin and proteoglycans. MMPs and cysteine cathepsins are co-distributed in dentin. CT-K and MMP-2 are both active, synergically. Once the cavity is directly exposed to bacteria, tubular invasion occurs. The most superficial part of the infected dentin becomes the zone of destruction.

**Active** lesions differ from **arrested** dentinal caries by its degree of pigmentation. Viable bacteria within the tubules, and a lower calcium content and hardness than the arrested decay characterize active lesions.

The lumens of the **sclerotic** layer are filled by non-apatitic mineralizations characterized by their crystallographic properties as weddellite, whewellite, calcite, brushite, whitlockite and octocalcium phosphate. The lumens of sclerotic dentin are filled with a dense calcified material. The intertubular zone is hypermineralized, and in continuity with the peritubular dentin. Reactionary and reparative dentins are formed within the pulp, in front of the carious lesion.

With the occurrence of rapid lesion progression, the odontoblastic processes are destroyed without having contribute to tubular sclerosis. Dentin dead tracts are found. Some of these tubules are invaded by bacteria, and groups of tubules may coalesce to form liquefaction foci.

It must be recognized that discoloration is one sign of carious lesions. Another sign is the softening of the tissues, including disintegration and eventually cavity formation. These characteristics of carious lesions are: 1) softening of the tissues, 2) discoloration and 3) wetness of the lesions. They are essential for differentiating active from arrested carious lesions, and moreover, the invaded layer from the affected layers [5].

In addition to mechanical removal of the soft carious dentin (using excavators, hand pieces and burs), other methods have been used. This is including air-abrasion (bumbarding the tooth surface with aluminium oxide, or alumina particles, expecting to reduce the problems of heat, and vibration). The methods so far used implicate also air-polishing ultrasonic instrumentation, and sono-abrasion.

Chemo-mechanical methods were more effective. The Caridex system containing N-monochloro-D,L-2-aminobutyrate (NMAB, GK-101E), was introduced, and was replaced by the carisolv gel. Carisolv consists of two carboxymethylcellulose based gels: a red gel containing 0.1 M amino acids (glutamic acid, leucine and lysine), NaCl, NaOH, erythrosine (added in order to make the gel visible during its use); and a second solution containing sodium

hypochlorite (NaOCl - 0.5% w/v). The two are mixed in equal parts at room temperature before use and then applied, using the hand instrument, onto the exposed carious dentine and left for 60 seconds prior to abrading away the softened dentine leaving a hard, caries-free surface. Current clinical techniques have been explored using lasers (Er YAG, carbon dioxide lasers, Excimer lasers). They were succesfully used in order to remove the carious dentine [6]. Case in phosphopeptide-amorphous calcium phosphate complexes (CCP-ACP) have the ability to stabilise high concentrations of calcium and phosphate in metastable solution, establishing an environment supersaturated with calcium and phosphate, inhibiting demineralisation and driving remineralisation [7].

Chemical methods using certain enzymes such as bacterial Achromobacter collagenase [8] or stromelysin -1 (MMP-3) [9] provide good results but request shorter periods of treatment. Using successfully a bacterial collagenase the soft carious dentin was removed without affecting the sound layers. Pronase, a nonspecific proteolytic enzyme from Streptomyces griseous helps to remove the soft carious dentin. Also a mixture of papain (a proteolytic enzyme eliminating only the partially degraded collagen molecule), chloramine (a disinfectant inactivating bacteria) and toluidine blue provided interesting results. The name of the gel is Papacarie, a chemomechanical caries removal agent [10].

## MINIMAL INTERVENTION DENTISTRY (MID), AND ATRAUMATIC RESTORATIVE TREATMENT (ART)

The concept of Minimal Intervention Dentistry (MID) is based on all the factors that affect the onset and progression of the disease. It integrates prevention and treatment. The field of minimal intervention dentistry is wide, including the detection of lesions as early as possible, the identification of risk factors (risk assessment), the implementation of preventive strategies and health education for the patient [11] Atraumatic Restorative Treatment (ART) concern mainly a Minimum Intervention Dentistry (MID) [12,13] In practice, glass-ionomer cements (GIC) are the most used material, with the advantage that the GIC has a delayed setting reaction that allows handling the material before it is completely set.

The term 'modified ART' appears frequently in dental publications. A modification refers to the fact that ART approach has been carried out in places where traditional dental equipment is not available. Therefore, « modification » is most often associated with the use of rotary equipment: to drill and open the tooth cavity, followed by the normal ART procedure.

ART is a minimally invasive approach to prevent dental caries and stop its progression. ART usually requires no unaesthetic restoration, and causes minimal discomfort to patients [14,15].

Minimally invasive dentistry, ultraconservative and micro-dentistry are terms that embrace operative restorative approaches which respect to the dental tissues and patient's comfort. The excavation of dentine caries is performed with the objective of preserving not only sound dentine but also the tissue which has the potential to remineralise. The Atraumatic

Restorative Treatment (ART) is part of our therapeutic armamentarium. It implies minimal intervention and is minimally invasive. Clinically, a cariology-based plan comprises three main phases: the diagnostic phase, the prophylactic phase the (recall) monitoring phase.

Atraumatic restorative treatment reduce dental anxiety in children. Administration of local anaesthesia is rarely required. However, the analysis of published studies showed that there is no difference between the ART approach and the conventional approach in reducing dental anxiety in children: ART was not more beneficial in reducing dental anxiety [16].

Dentin bonding agent (DBA) was to bound to the organic component of dentin, namely the collagen [17] The term « hybrid layer » or « resin-dentin interdiffusion zone » or « resin-impregnated layer » referred to a mechanism of bonding of resin-based DBAs via a hybrid layer [18].

The effectiveness of ART restorations is assessed by their survival. The most recent meta-analyses on the performance of ART restorations concluded that:

- ART using high-viscosity glass-ionomer can safely be used in single-surface cavities in both primary and permanent posterior teeth;
- ART using high-viscosity glass-ionomer cannot be routinely used in multiple-surface cavities in primary posterior teeth;
- Insufficient information is available for conclusions about ART restorations in multiple-surfaces in permanent posterior teeth, and in anterior teeth in both dentitions [19].

It was shown that bacteria remain present after complete hand excavation with in the tubuli of affected dentin. The potential caries risk due to the remaining bacteria can be successfully controlled by reducing bacteria and through remineralisation. Caries activity can be decreased through effective nutrient deprivation by sealing the cavity using filling materials which chemically bond to the cavity walls and which assist remineralisation of affected dentin through long time fluoride and mineral release [15].

## ART FAILURES

Clinical factors responsible for ART failures are material factors, operator and technique factors. The prevention and management of ART failures includes emphasis on correct clinical indication and the repair of failed restorations.

The classification of sites follows the three surface areas on which more frequently caries occurs.

- Site 1: pits & fissures (occlusal and other smooth tooth surfaces)
- Site 2: contact area between two adjacent teeth

Site 3: cervical area in contact with gingival tissues

The main reason for clinical ART failures are related to operator skills and performance [20] After 12 months, Class II/

multisurface and Class III/IV ART restorations have generally shown success rates of approximately 55-75% and 35-55%, respectively. Failures results usually from restoration losses and fractures. Class I & V/single-surface restorations have much better short-term success rates (approximately 80-90% [21].

Minimal intervention dentistry is part of pediatric dentistry. The caries risk assessment for infants and young children is presumably under the control of increased caries prevalence. Perinatal oral health is important in preventing early childhood caries. Providing dental treatments to expectant mothers contribute to the long-lasting oral health for young patients. General dental practice may adopt protocols that will promote early preventive visits and guidance rather than waiting for the need of restorative treatment [22].

## CONCLUSION

It has been shown that the fluoridation of water reduced the prevalence of dentine lesions by approximately 50%. The main long-term action of fluoride is retarding the progression of carious lesions, rather than prevention of its development. It has been showed that only the 'infected' ('outer carious' or 'decomposed') dentin needed to be removed as part of the cavity preparation process, and that the 'affected' ('inner carious' or 'demineralised') dentin could remain, even with bacteria in a small number of tubules. This demineralised dentin would remineralise under a well placed, well sealed restoration. A new area for Atraumatic Restorative Treatment (ART) was instored, and three aspects were promoted : early caries detection and caries risk assessment; remineralisation of dentine and optimal caries-preventive measures.

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