Changing Concepts in Cariology: Forty Years On

Abstract: The caries lesion is a sign or symptom resulting from numerous pH fluctuations in biofilms on teeth. The lesion may or may not progress and lesion progression can be controlled, slowed down or arrested. Control of the biofilm is the treatment of caries, the most important measure being to disturb the biofilm mechanically using a fluoride-containing toothpaste. The informed patient controls caries and the role of the dental professional is to advise how this should be done. This is the non-operative treatment of caries and it is worthy of payment. It should be mandatory as part of any operative treatment to ensure that the patient understands, and is able to perform, adequate plaque control.

Clinical Relevance: It is very unfortunate that the current remuneration scheme (Unit of Dental Activity) in Health Service practice in England and Wales prevents practitioners adopting a modern biological approach to caries control.


Changing concepts in cariology: forty years on

Forty years on, when afar and asunder Parted are those who are reading today, When you look back, and forgetfully wonder What you were like in your work and your play, Then, it may be, there will often come o'er you, Glimpses of past and some of it wrong, Visions of studies shall float them before you, Echoes of teaching shall bear you long, What is new for the patient our hope to fulfil, Teeth unto death are chiefly our will. (With apologies to Edward Ernest Bowen and Harrow School.)

A personal introduction

Edwina Kidd was in the staff room at the London Hospital Dental School when Ted Renson carried in his baby, Dental Update, Volume 1, Number 1. It was a revelation to see such a beautifully produced, colour illustrated and readily understandable production. The cariology article in that first number concerned the white spot lesion and was written by Leon Silverstone. The authors of the current paper (EK and OF) met in Leon’s laboratory (a euphemism for a large cupboard) at the London Hospital at that time. One (EK) was a junior lecturer at The London whose PhD Leon was supervising; the other (OF), already a Professor of Oral Pathology in Denmark, had recently been appointed to a chair in Cariology and needed to change research focus from soft to hard tissues. He was in London to research aspects of fluorosis and work with Leon, Newell Johnson and Ron Fearnhead. Having met in a long, thin cupboard, where communication was inevitable, we subsequently worked together for 40 years (Figure 1). We now combine in this anniversary issue to take a helicopter journey over contemporary Cariology, discussing aspects of the subject as understood in 2013 and highlighting changes in understanding from the 1970s.

The relevance of cariology

Dental caries is ubiquitous – it is omnipresent in all populations and as old as mankind. The caries incidence rate varies extensively between and within populations. With increasing age, signs and symptoms of dental caries accumulate and, in most adult populations, the caries prevalence approaches 100 percent. Prevention and operative treatment of caries lesions, and their sequelae, occupy the majority of the dental profession life-long around the
world and the cost of dental health care is a major societal burden. The majority of dental restorations are made because of dental caries. Caries and failed restorative care are the main causes for tooth loss in all contemporary populations.

The current concept of caries and caries control

Dental caries is a dynamic process. It is a chemical dissolution brought about by metabolic activity in a microbial deposit (biofilm) covering a tooth surface at any given time. Over time the outcome of these fluctuations may result in a disturbance of the equilibrium between the tooth mineral and the surroundings. Mineral loss, subsequent lesion formation and possible cavity formation in teeth, is a symptom of imbalance in this dynamic process. The metabolism in the biofilm is an ubiquitous, natural process; part of having teeth. However, its possible consequence, lesion formation and progression, can be controlled so that a clinically visible lesion never forms or an established lesion arrests.¹

The following points encapsulate our current view of caries:²
- Caries is ubiquitous;
- It is a sign or symptom resulting from numerous pH fluctuations in biofilms on teeth. The resulting de- and re-mineralization of the tooth surface may result in the formation of a clinically detectable lesion (the sign/symptom);
- These lesions may or may not progress;
- Lesion progression can be controlled, slowed down or arrested;
- Everyone is at risk of lesion formation from cradle to grave;
- Caries is the predominant cause of tooth loss in all ages.

In the 1970s, it was suggested that caries could be prevented and the concept of caries control was not emphasized. The distinction between the process in the biofilm and its reflection, the lesion in the tooth, was not made clear. Although it was realized that all ages were susceptible to caries, prevention was mainly taught in paediatric departments, and it was suggested that periodontal disease was the more important cause of tooth loss in the elderly.

When GV Black published his comprehensive textbook in 1908⁴ he emphasized that clinical diagnosis and treatment decisions should have a sound biologic rationale. Although it became appreciated by the middle of the 20th Century that dentistry is a biomedical specialty, the technical advances with high-speed drilling seemed to distort the true application of biological knowledge in the optimal treatment of dental caries. Dental caries became synonymous with ‘a cavity’ in the tooth and the automatic reaction was that the treatment should be ‘drill and fill’.

In the growing field of caries epidemiology, dental caries was recorded as DMF teeth/surfaces where D stood for Decay and decay meant a cavity. The knowledge about aetiology and pathology of caries was often taught in dental curricula in departments of microbiology, pathology and physiology, as well as in the growing disciplines of the 50s and 60s of dental public health, departments of paediatrics and preventive dentistry. However, the clinical relevance of cariology¹⁴ to restorative clinical departments was not emphasized in all schools (The London being a notable exception!) and knowledge to be applied at the chairside was fragmented. To some extent this was understandable because, in a clinical department, the students were supposed to produce fillings and crowns and bridges. Thus the appreciation of the need for concomitant disease control as part of any long-term successful restorative treatment was limited, or non-existent.

What constitutes treatment of caries?

This question is incredibly important. Since lesion formation and progression can be controlled, control of the biofilm is the treatment of caries. The most important control measure is to clean teeth regularly, and thus disturb the biofilm mechanically, with a fluoride-containing toothpaste. If sugar intake is high and frequent, the pH fluctuations in the biofilm may result in overgrowth of cariogenic micro-organisms, making lesion formation and progression more likely.⁵ Thus dietary advice may have a role to play. From these statements it is obvious that it is the informed patient that actually controls caries. So what then is the role of the dental professional? It is to advise, so that all our patients are aware of the importance of good tooth-cleaning, appropriate use of fluoride and a sensible diet. This is the non-operative treatment of caries. Note that the examination of the patient and giving appropriate advice are time-consuming, skilful and worthy of payment. However, in the 1970s treatment (as opposed to prevention) of caries was by filling teeth, which is very unfortunate because fillings mask the problem of poor plaque control and the dentist takes responsibility away from the patient. ‘You have decay, let me treat it for you by cutting it away and replacing with a filling.’ Fillings are even claimed by some to be ‘secondary prevention’ which is nonsense! For a while fillings will appear to be successful, but if the real cause of the problem is not addressed, caries will recur adjacent to the filling. To place restorations without addressing the reason the lesion has formed in the first place is tantamount to repairing a fire damaged building without extinguishing the flames. Fillings are a part of plaque control and important in the management of cavitated lesions, but they are not the most important aspect of caries control.

Forty years ago, in the United Kingdom and Denmark, there were departments of conservative, operative or restorative dentistry where, although the pathology of dental caries might be taught, rewards were only given for fillings. Undergraduates had points quotas with points given for restorations. There were no similar rewards for non-operative treatments. Students would thus qualify for operative dentistry (fee per item of operative treatment) but not for the non-operative caries control measures.

It is now tempting to take a sneaky look across the Atlantic where, even today, there are few departments of cariology and operative dentistry reigns supreme. This is of great importance to the young dentist who is emerging from the dental school egg with debts of a quarter of a million pounds. And before
Caries diagnosis

A diagnosis has been described as a mental resting place on the way to a treatment decision. What in diagnosis is relevant to that treatment decision as far as caries is concerned? The activity of the lesion is of great importance (Figure 2). Lesions judged as active (by this we mean if nothing changes, the lesion will progress) require non-operative treatments and a review of the efficacy of the treatment is to check that lesions do not progress and appear to be arrested.

The other aspect of great relevance is whether a cavity is present that traps plaque and precludes cleaning (Figure 3). If the patient cannot access the plaque, the lesion is almost bound to progress. These lesions must either be filled or perhaps made accessible to cleaning.

Radiographs are an aid to diagnosis for approximal lesions. However, while a radiograph gives some appreciation of lesion depth, a single radiograph cannot assess either activity or cavitation. It must also be remembered that there may be false positive and negative findings on these two-dimensional shadows. Radiographs do not alone define the truth. A subsequent picture, taken after a period of time with a film holder and beam aiming device to ensure comparable geometry, should be examined for lesion progression or arrest.

Decisions, about activity and cavitation, are inevitably best guesses. This is not a disaster because dentists should review patients and thus review the decisions. However, the opportunity for review should have implications for decision-making. If a lesion is suspected as active, it should be treated non-operatively so as not to miss the opportunity to arrest the lesion. However, if a dentist is unsure whether an approximal lesion is cavitated, and therefore unsure whether a filling is required, the better decision is to institute non-operative treatment and reassess rather than prescribe a restoration because this is an irrevocable decision. We know from research started at the London Hospital by Richard Elderton in the early 1970s, that placement of a restoration may start a cascade of restoration and re-restoration, each replacement resulting in further tooth removal, until we simply run out of hard tissue and the tooth is lost.

In the 1970s, there was no appreciation of the relevance of lesion activity to the treatment decision. Approximal lesions tended to be treated operatively when they were just in dentine on radiograph – and in Denmark even when confined to enamel. The current threshold for operative treatment, in contemporary low caries populations, tends to be lesions that are well into dentine because the less advanced lesions are often not cavitated when opened. These should be treated non-operatively and thus given a chance to arrest following improved oral hygiene and fluoride application.

In the 1980s and 1990s, there was a flurry of activity in the use of machines to aid diagnosis, for example electrical conductance measurements and fluorescence techniques, such as DIAGNOdent (KaVo, Biberach, Germany). The idea was to take the subjectivity out of the task as well as to diagnose demineralization at an earlier stage so that non-operative caries control measures could be instituted in a timely fashion. After considerable research effort, and many publications, it was acknowledged that these machines can only detect demineralization and not...
make judgements on what matters most, namely activity and cavitation. It was thus eventually concluded that a visual-tactile examination of clean, dry teeth, together with careful thought, were preferable to any machine.9

Occlusal lesions have given particular food for thought. In the 1970s, it was considered that the lesion formed in the depth of the fissure and was difficult to see and impossible to access for thorough cleaning. In the 1980s, dentists noticed that they were missing quite advanced lesions on clinical examination but finding large lesions in dentine on radiograph (Figure 4). The term ‘hidden caries’ was used to describe lesions missed on clinical examination but found on radiograph, and fluoride was blamed for masking the diagnosis. It was subsequently shown that the occlusal lesion forms at the entrance to the fissure and it can be diagnosed visually, provided plaque is removed from the fissure entrance. This was a very important finding because it implied that these lesions could be controlled by cleaning alone. The erupting premolar/molar, in particular, should be carefully cleaned by a parent, with the brush coming in at right angles to the arch (Figure 5). Occlusal lesions can be prevented/controlled by careful cleaning over the eruption period, and fissure sealants are not required.10

Unfortunately, the profession seems to have been very slow in adopting a chart that allows the salient features of lesion activity and cavitation to be visually recorded, although such a chart has been developed (Figure 6) and described in Dental Update!11

**Assessment of caries risk**

**Question:** Who is at risk from lesion development? **Answer:** Everyone with teeth, from cradle to grave, because the metabolism in the biofilm is a natural part of having teeth. In recent years, there has been much interest in whether lesion activity and cavitation to be visually assessed will also guide appropriate recall intervals. After much research, it can be stated that no single factor or combination of biological factors will accurately predict risk, on an individual patient basis, except the presence of early non-cavitated lesions and a history of lesions and fillings.12 This makes a careful clinical visual-tactile diagnosis even more important. However, all our patients should be taught good oral hygiene with a fluoride-containing toothpaste and the relevance of diet to caries. This is called a whole population approach and is appropriate to any disease that potentially occurs in everyone.

The one factor that will predict increased risk is dramatically reduced salivary flow (hyposalivation). Resting flow should be measured when this is suspected because, if the clinician’s suspicion is confirmed, the patient is at risk of rapid lesion development. Frequent recall and strenuous effort will be required to control lesion progression in these types of patients. The management majors on plaque control and fluoride (Figure 7). These are some of the most difficult patients to manage; those one worries about in the darker reaches of the night.

**Epidemiology**

It was in the early 1980s that data from around the developed world showed a decline in caries prevalence and incidence (rate of development). In UK, decennial National Surveys have shown this decline. In Denmark, all children enrolled in the school dental health service were examined annually, resulting in unique longitudinal data. Initially, the caries decline caused some panic. If dental caries was solved, what were dentists to do? Several dental schools closed in the developed world and, ironically, in England the school that trained therapists was also closed. The dental profession was climbing into the boat and pushing off. After a few years it was realized that the decline in caries prevalence and incidence, far from obviating the need for dentists, actually might require more dental personnel because there are so many more teeth to look after. Why have there been changes in caries prevalence...
and incidence? The likely explanation would seem to be the advent of fluoride, particularly in toothpaste. It should also be noted that caries distribution in populations is now more and more skew and often concentrated in socially deprived people, to the extent that rampant caries in a child should make the dentist consider whether the child is seriously neglected.

The role of plaque control

Since the metabolism in the biofilm is responsible for caries lesion development, plaque control is the most important part of non-operative treatment.

The role of fluoride

So if fluoride explains much of this alteration, what is its mechanism of action? In the 1970s, it was thought that, to be effective, fluoride had to be incorporated into developing enamel and the fluoridated apatite so formed would be more resistant to acid attack. Several studies had shown the significant effect of fluoridated water on dental caries, not least in the United States and Holland. This concept of incorporation into enamel would basically mean that children, in particular, would be the target group for fluoride prevention. However, in 1981, one of the cupboard companions (OF), together with two Danish colleagues, put together the evidence from research works around the world to show that the important mechanism of fluoride was its topical effect. Fluoride, present at the point of acid attack in the oral fluids, delays lesion development and progression and it does it at any age. The fluoride does not have to be in water, it can be in toothpaste, mouthwash, varnish, gels. All systemic effects may result in unnecessary development of dental fluorosis but are not needed to obtain maximum caries control. It should also be appreciated that changing criteria for the decision to restore has resulted in fewer fillings and this has also played a major role for the change in DMFT in many countries.

The role of diet

The evidence linking sugar and caries is irrefutable, although there is no linear relationship between daily sugar consumption and caries experience on a population basis. Unfortunately, there is less evidence that it is possible to alter diets and persuade people to eat differently. We only have to consider the current obesity epidemic to realize the difficulty. Caries decline occurs in most populations without a concomitant decrease in sugar consumption (Figure 8). Changes in socio-economic conditions, widespread use of fluorides, increased appreciation of the role of oral hygiene and changing restorative thresholds have had a major impact on the caries situation. For this reason, our major focus in caries control should move from diet to oral hygiene, with a fluoride-containing toothpaste. However, this does not mean that we should ignore diet. All our patients should be aware of the relationship of sugar to caries and dietary advice is still needed in those developing several new lesions at any stage in life. It is especially important for those with decreased salivary flow, where dietary advice is mandatory.

When do we need fillings?

As discussed earlier, from a purely cariologic perspective, fillings should be considered a somewhat strange way of performing plaque control! Thus they are required when the patient cannot clean plaque out of a hole in a tooth, for instance a cavitated occlusal (Figures 3a and 4) or an approximal surface. This means that many root caries lesions do
Figure 8. The blue bars show the decline in caries experience (DMFT) in Denmark in 12-year-old children between 1974 and 1997. This pattern is typical of developed countries. The red bars show the sugar consumption (kg/individual/year over the same years). The decline in caries is not likely to be due to changed sugar consumption because this has not changed.

Figure 9. (a, b) There are 8 years between the two photographs. In (a) the root lesions are active, plaque-covered and soft to gentle probing. In (b) the lesions are arrested, hard and shiny. The non-operative treatment has involved removal of a rim of unsupported enamel at the occlusal aspect of the lesion, and daily plaque removal with fluoride toothpaste. The lesions are not visible and do not need restoration.

Figure 10. (a) Cervical lesions covered by plaque. (b) The same cavities 14 days later after removing overhanging enamel and showing the patient how to clean. The teeth were then brushed twice a day with a toothbrush and fluoride paste. At this stage, from a cariological point of view, these lesions were stable but very ugly. For this reason, they were restored with composite (c). This was taken immediately after removal of the rubber dam and the teeth had dried out, which explains a small colour difference that will disappear rapidly as the teeth rehydrate.

There was a fee for scaling and polishing and one of us (EK) used this fee to cover preventive advice. In her hands money was lost, but it did not haemorrhage.

In 2006 the fee structure was altered, with a new contract, and fees were divided into three bands. This system is still in operation and, in the opinion of one of the authors (EK), it is a problem and should have been discontinued long ago. Non-operative treatments are part of Band 1 which comprises diagnosis, treatment planning and maintenance, attracting a single Unit of Dental Activity (UDA), which will represent about 15 minutes of surgery time at best. For this fee the practitioner should carry out:

Delivery of caries control treatments in the NHS in England and Wales

When Dental Update was born practitioners were rewarded on a fee per item of operative treatment basis. There were no fees for preventive treatments, such as oral hygiene instruction, fluoride application, diet analysis and fissure sealant application.

1970s. Lesions, as seen in Figure 9, would have been restored and this was not easy because suitable adhesive restorative materials were in their infancy and even these cannot last forever.16

In the 1970s, fissure sealants were recently developed and were applied to sound fissures to prevent lesion formation on molars and premolars. Remember that the caries prevalence was much higher in those years. However, the contemporary indications for sealants are much less. Caries prevalence is reduced, it is unusual to see occlusal lesions in premolars and occlusal lesion formation can be controlled by cleaning with fluoride toothpaste. The contemporary indication for sealants would be in patients who are not cleaning effectively, despite advice.
functioning dentition from cradle to grave. In the upcoming third edition of our mutual textbook, we will soon document how this goal is achievable today. Indeed, it has been achievable for many years with the knowledge that we now have about the nature of dental caries.

Acknowledgements

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The dentist who took each photograph and cared for the patient is acknowledged by a ‘signature’ on the picture. This acknowledgement is important because illustrations of this quality are difficult to produce but invaluable teaching material.

References


Further reading