

Part 4; - Ozone in Clinical Care part 2.

In this article, Dr Julian Holmes explores arguably the most important advance in caries management since the development of filling materials and antibiotics.

Introduction. Over the years, general dental practitioners have been, and continue to be, bombarded with information promoting new and improved innovations that will assist them in enhancing their clinical and marketing skills. It is now generally accepted that there is a vast range of products available to improve patient communication and education by showing them the state of their oral health and highlighting problem areas. These devices help to sell dental care and treatment, allowing the practitioner to show x-rays almost instantly and store libraries of photographs of their patients.

You can now buy anything from high technology imaging products down to the clever but simple dyes that make plaque and caries visible. To date, in many dental practices worldwide, caries detection and, therefore, the elimination of decay depends upon visual recognition with the aid of a mirror, probe and x-ray analysis. Studies that you can search through PubMed have shown that these traditional systems can be inaccurate and tests to look for the propensity of the individual to decay offer little more accuracy.

Let's briefly review the theory of the development of a carious lesion as this is crucial to the understanding of the new technologies to be discussed. The 'niche environment theory' is now accepted to explain the process of initial colonisation through to the development of acidophilic micro-organisms in a specialised niche environment. As the bacteria collect, for instance in a fissure, they produce acid, which leads to the loss of mineral content in the enamel surface. This is known as demineralisation. This is offset to some extent by the balance between demineralisation of the enamel surface by these acids and remineralisation by the host's normal neutral/basic oral environment. As the numbers of acidophilic bacteria increase, the niche becomes predominately acidic, attracting more acid-producing bacterial species and, over time, a cavity forms.

The process of niche development may take many years. We already know from previous studies that decay can be reversed by improved oral care and the use of mineral mouthwashes and dentifrices. Failure to find a cure for dental decay may be due to the change in the type and species of micro-organisms in caries development. The dental profession and pharmaceutical companies have searched in vain for a simple system to prevent and cure caries; varnishes and tablets have been developed with little success. One reason that they have not succeeded would seem to be the change over time in the type and species of the microorganisms involved, from the process of colonisation to the establishment of the developing lesion. And while fluoride has undoubtedly reduced the incidence of decay, the prevalence of decay in my practicing career area has seen a noticeable increase, possibly due to the amount of bottled mineral water being drunk.

Surely, therefore, the profession should welcome technology that makes caries detection simple and that will kill all the micro-organisms on in a tooth surface, leaving it virtually sterile. This technology may allow the tooth surface to remineralise, encouraged by the patient's saliva, mouthwashes and dentifrice and, where caries is already established, halt its progression and allow the area to 'heal' without amputation of tooth material to remove tissue that we consider to be infected. All, of course, without the need for anaesthesia in already sensitive gum tissue.

Ozone. The good news is that at last we have such a technology and, more to the point, it is available in throughout the world. KaVo released the caries-detecting DIAGNOdent in 1997, followed by the HealOzone in 2001, which employs an ozone generating source. The HealOzone was the first dedicated dental ozone unit. By 2003 competing units were available, such as the early model of the Ozi-cure from O3 in South Africa and the CMU3 & 4 from GCE Ireland. With the advent of new units with different delivery systems, dental treatment with ozone has become fast, predictable, and has now expanded into every facet of dental care.

Ozone technology has been researched over a number of years in Belfast University under the watchful eye of Professor Edward Lynch who is now at Warwick University. The published studies fulfil the profession's wildest dreams.

Yet the use of ozone in health care is not new. In 1885, the Florida Medical Journal published the results of using ozone in a variety of diseases and infections. In 1904, a medical book entitled 'The Therapeutic Applications of Hydrozone and Glycozone' was published in New York. By 1914 the entire London Underground at that time had its air treated with ozone to reduce potential cross infection.

Ozone kills >99% of all bacteria, fungi and viruses. The systems are based on ozone (O₃) gas. Ozone forms part of the natural gas mix that surrounds the Earth at high altitude and protects the world's population from excessive ultra-violet radiation. That fresh, wonderful smell on the mountains when you ski or after thunderstorms is ozone. The medical profession has used ozone for some 100 years with much research being carried out, especially in Russia and Cuba.

In my quest for knowledge, a search of 'ozone medicine uses' on the internet brought up hundreds of references on the topic. All of the information studied showed that the elimination of all bacteria, viruses and fungi is possible through the application of ozone. Ozone has also been used in commercial applications for over a century and is now used to purify public water supplies in cities worldwide. O₃ is also used to eliminate pollution in air supplies in hospitals and other buildings – for example in the terminals at London Heathrow.

The early published research from 2000 onwards showed that ozone readily penetrates through decayed tissue, eliminating any bacteria, fungi and viral contamination. The chemistry of the lesion tissue changed from acidic to basic, and it would be expected that this 'clean' lesion should remineralise if the right environment conditions were set up. These would include oral hygiene, diet, correct assessment and mineral mouth rinses.

Results. The early studies concentrated on looking at single-surface lesions, where ozone was the only agent used. In the primary root carious lesion studies, the research showed that just 10 seconds of treatment with ozone eliminated 99% of the microorganisms; over 70% of the lesions studied reversed or improved, the remainder did not progress. More importantly, not a single lesion deteriorated. This study was compared against a control group where 80% progressed further. Results from the fissure caries study show even better results of caries reversal.

In my own practice between 2002 to 2004, our studies showed that at three and four month recall not a single lesion identified as a carious lesion has progressed; the majority of lesions showed remineralisation had occurred. Also, as the treatment is simple, does not involve any

injections, drilling or discomfort, our patients loved it. Faced with the options of an injection, amputation of part of your tooth, filling and its eventual replacement sometime in the future, what would you go for? And when we do come across a lesion that has not responded to the ozone treatment, we could revert to the conventional filling systems.

However, when ozone treatment was combined with traditional dental care, the real power of this system was revealed. As the practice and research developed, ozone was found to have a use in each and every treatment facet. No longer were we involved in wholesale tooth destruction to remove all the potentially infected dentine; and suddenly it was ok to leave a bit of infection behind - we knew ozone would eliminate the infection and allow tissue hardening over time by remineralisation. From routine fissure sealants to implant placement, ozone had a role to improve the clinical standard of care. Ozone had made that important move from a treatment modality in isolation, to its pole position as being an adjunct to conventional care, with the emphasis on limited tissue "amputation". This was a huge step away from the Victorian principles of "extension for prevention" where tooth obliteration was the norm so it could not decay! Today the concepts of minimal- preparations have been pushed aside by the principles of micro-preparation. The dental profession had to adopt new ways to look at their treatment subjects - teeth that is! Loupes, operating magnification, intense local lighting, and operating microscopes all started to influence the way the dental profession carried out its business.

Ozone technology potential. This technology has many other indications, including the decontamination of dental unit water lines that are especially vulnerable to bacterial contamination and colony growth due to the static layer of water at the inner tube surface or surface bacterial growth known as a "biofilm". Other uses include the treatment of periodontal disease and the re-washing of surgical sites prior to, for example, implant placement. A number of studies have been undertaken to examine the cleaning of root canals utilising ozone, and ozone dissolved in water, in endodontic treatment. Ozone can be used as an accelerator during tooth whitening. New studies in Europe and India are looking at periodontal treatment with ozone, and in Egypt looking at a tray application for prevention, as well as accelerated hard and soft tissue healing around dental implants. In this study, at 8 weeks we saw the equivalent of 6-month post implant placement bone maturity around the dental implants.

If you want to learn more about this technology, help can be found at www.the-o-zone.cc where you can find out about ozone and how it is used in practice, as well as news about upcoming lectures and presentations on this technology. The lecture series is presented by Professor Edward Lynch, Dr Julian Holmes and members of the research team from Queens University. The presentations cover basic research, the quest for a simple effective system to eliminate decay, and how to use, market and cost it in practice.

In this second part, Dr Julian Holmes explores arguably the most important advance in dental infection control or caries management since the development of filling materials. Dr Julian Holmes explains how dental ozone is used and what lessons are to be learnt about this new technology. New technologies can have the most profound effect, and not only on the public's desire for treatment. **Introduction**

Early 'Prevention'. Prevention with fissure sealants has been problematical for the dental profession. Fissure sealants have been shown to leak, and cause decay. Some practitioners are old enough to remember the first fissure sealant preventative systems. We used these fissure sealants on teeth that were most at risk to decay, namely the first permanent molars, and by the time we got to treat these teeth, the fissure patterns were already stained.

We used pumice to clean the tooth surface with a bristle brush, acid-etched the enamel surface, floated on the mixed varnish and waited for it to set. As an undergraduate, I was taught that once the sealant had been applied, no food substrate could reach any bacteria trapped deep in the fissures, so the carious process would halt. I now realise that, of course, the bristles could not clean out the fissure pattern totally, so most of the contaminated debris was probably left in situ and we are aware that some bacteria are unaffected by acid etchants. I suspect that, like me, many of my contemporaries have seen cases years later where the decay process has slowly continued, leaving a hollow shell of enamel.

This is explained by micro-leakage around the margins, allowing the ingress of food substrates to the trapped bacterial colonies, and minute fissures that remain unsealed, allowed bacterial substrate ingress and caries development. Later research has shown that the bristle tips - quite apart from the tip of a dental probe, cannot engage with the full depth of the fissure we are supposed to evaluate or clean. Little wonder this early preventative approach lead to frustration and failures.

The introduction of 'minimal-invasive dentistry', with a range of fine diamond coated dental burrs opened the way to treat fissures with conservation in mind - the tissue removed in preparation was reduced. Advances in vision, lighting and air-turbines reduced the tissue destruction still further. Where caries was found, dyes showed the extent of the demineralised tissue, and products such as Cari-Solv could be used to remove the denatured tooth tissue, rather than macro-tissue destruction with dental burrs.

Treatment was improved by the introduction of air-abrasion. A minute stream of abrasive particles was used to clean out the impacted debris, open the fissure pattern to allow visualisation and diagnosis, and then a micro-filling of preventative filling could be placed. This treatment modality heralded the advent of 'micro-dentistry'.

However, most of these systems were removed to that wonderful store cupboard to be found in every practice - stuff we buy, use a couple of times, and then stop as time is a constraint that eventually gets to every dental practitioner. What the dental profession really needed was a system that eliminated the infection, without the need for wholesale tissue destruction that was fast, very easy, and as number 1 on the list, was predictable.

Not only does the dental practitioner want treatment to be predictable, but so does every patient that passes through the dental profession's clinics around the world. And at the end of the 20th Century, dental treatment was anything but predictable. Statistics from the UK show that even in 2004, the average life span of a restoration placed in socialised system or State-funded clinic was just 9 months! Where in some countries the state paid each time a filling was placed, one can understand the need to replace fillings to maximise income. However, from a patients' point of view, dental treatment was synonymous with a cash-cow, no filling lasted longer than a year, and of greater importance, the surrounding tooth tissue was gradually - or suddenly (depending on the manual dexterity of the dentist concerned) reduced in volume, with certain failure at some time in the future - or replacement! - being the

accepted norm.

In a simple, but effective exercise, Professor Edward Lynch and Dr Julian Holmes evaluated that if a system that saved tooth tissue could be introduced into a socialised system, there were huge financial gains for;

- the state in terms of reduced funded dental care, lost work time;
- for the patient, in terms of reduced cost and time off work;
- for the dental practitioner, in terms of increased income, reduced time, reduced failure, and enhanced 'professionalism';

This could be extended to every country in the world. And ozone offered just this pathway.

Stains Versus Early Carious Lesions. So how can we improve our diagnosis of a stain versus an early carious lesion, as this is one of the hardest diagnoses to make? Part of the research into ozone technologies was to look at a reliable and reproducible way to measure decay. The DIAGNOdent has been available since 1997 in Europe and works by shining a laser at the tooth surface. Once calibrated to the patient, the level of decay is expressed as a number on the screen and as an audible tone. The higher the number and tone pitch, the larger or more extensive the area of decay. What the machine actually measures is the fluorescence of bacteria and, indirectly, the density of tooth structure and the presence of decay. It is not without its own problems, and every dental practitioner needs to be aware the limitations of each technology brought in to aid clinical diagnosis.

The humble mirror, probe and x-ray have been shown to have severe limitations in their ability to 'diagnose' caries. These implements do not really diagnose - they are an aid to data gathering that allow the dental practitioner to make an informed decision as to the clinical requirements. Sadly with a diagnostic criteria of just 50% or worse as shown by some studies by Professor Adrian Lussi in the late 1990's, dental practitioners make an informed guess as to what they are looking at.

The late 1990's saw an increase in the equipment that the dental practitioner used to evaluate a tooth surface - magnification, improved lighting, and knowledge. But the key to making a diagnosis of if decay was present or not, was still a hit-or-miss affair. Research started to show that the 'simple' fissure pattern was anything but simple! Dental practitioners were told to sharpen the probes - then to blunt them as sharp probes could cause decay to start! Then of course the profession discovered without a sharp probe not a great deal can be found with what had become a pointer at best. Then came the publications from New Zealand and the USA that showed fissures were 'bottle-shaped'- narrow at the top, opening to a large open area, that usually had decay at the depths and on the walls, intact occlusal enamel over laying caries, and the concept of 'hidden-decay'.

Clearly the dental profession needed a new diagnostic system that allowed improved diagnosis and evaluation, without the need to drill open every occlusal surface just to look inside - and of course, if the dental practitioner was using a mirror and probe to look, they would not 'see' the incipient demineralisation that would lead to decay or even the early lesion. The DIAGNOdent was a huge leap forward in the ability to diagnose the incipient lesion, the demineralisation of enamel, and what was going on at depth under that seemingly pristine enamel surface.

But even the DIAGNOdent has limitations. For instance, it can be fooled by fluorescence that is non-bacterial - eg composites. The advent of natural polymers that mimic tooth material has been one of the major leaps forward in cosmetic dental care. As the DIAGNOdent relies on fluorescence to 'diagnose' decay, any pre-existing sealants or fillings that have a fluorescent quality have to be removed, or allowances in the DIAGNOdent assessment made. The maximum value that the DIAGNOdent can display is 99. At 98, you may have a true number and assessment of the lesion. But at 99, the assessment could be 99, or 120, or 250! You just do not know due to the physical limitations of the equipment. Just before those who use the technology place their DIAGNOdent in the store room or others contact me to complain at my comment, please stop there! In my opinion, this technology should be used by **EVERY** dental practitioner, should be taught at dental schools, and should be one of the few required dental instruments that every evaluation is made with. It must be stressed that the DIAGNOdent is a scientific instrument, should be handled with care, and be properly calibrated **EVERY** time it is used, and then cleaned (Note! you can of course use ozone to disinfect and sterilise the tip - it is fast, predictable, and works.)

But aside from that slight digression, the DIAGNOdent takes away the guessed diagnosis, and gives the practitioner the scientific basis to decide to leave the tooth surface, or start treatment on it. So in the ozone technologies - irrespective of which ozone device you choose to buy, use the DIAGNOdent to assess the treatment needs, and the entry criteria. And then, put it to one side, as the research has shown that remineralisation - part of the 'healing' process following ozone treatment of an area of decay, will take up minerals, as well as stains. So the use of the DIAGNOdent to assess remineralisation is not a useful criteria as stains may give a false=positive, leading to further unnecessary dental treatment on a 'healed' and reversed lesion.

For assessment after ozone treatment, the Clinical Severity Index, the CSI, is a far more useful tool, as this combines all the clinical criteria dentists were taught at dental school, but somehow forgot as the holy cows called 'Mirror & Probe' took over. These are useful tools to point out the short comings of the efforts of oral hygiene in embrasures or around orthodontic brackets, or debris collections below the nasal passageways, or even wax from the auditory canal. But as **diagnostic** tools, forget them. Move on to a scientific system that actually will show you where you need to take a closer look.

Once the fissure pattern has been opened, the walls and floor assessed, then treatment requirement criteria can be made, and an informed treatment plan drawn up with the patient. What the use of the DIAGNOdent does more than any other tool in the dental practice - with the possible exception of the intra-oral camera - is bring the patient into their own treatment planning, and by giving the patient information, teaching and informing that person will allow them to make their own informed decisions about their dental - or medical - care.

Reliable Data. In my practice, we used the PROPHYflex System from KaVo to clean the surface thoroughly, ensuring the DIAGNOdent measurement is not caused by impacted debris or stains. The working tip of the PROPHYflex pushes out a slurry mix of sodium bicarbonate and water, and it is very effective at stain and debris removal. You could use routine air abrasion.

The DIAGNOdent is then used to measure the occlusal areas that are suspect. We designed a custom screen in our computer management system to record this data. On molar teeth, we used the intraoral camera system first to photograph the tooth and then add notes of the

readings over the surfaces. We note and treat values up to 10 with a preventative dose of ozone – 20 seconds is all that entire surface needs. The preventative aspect of ozone in dental care has not been reported on yet as a research topic, but it makes sense, as any areas of enamel demineralisation are treated at a very early stage of lesion formation. In the past, we would have treated any surfaces with readings of 10 to 15 using air abrasion and fissure sealants. We would now recommend the use of ozone to reverse the demineralisation that has been found. Moreover, with values over 20 where we would have removed tissue with either air abrasion or a drill, we now offer ozone as an alternative.

The Ekstrand Index has 7 groups as follows;

0	No or slight change in enamel translucency after prolonged air drying (>5s)
1	Opacity (white) hardly visible on the wet surface, but distinctly visible after air drying
1a	Opacity (brown) hardly visible on the wet surface, but distinctly visible after air drying
2	Opacity (white) distinctly visible without air-drying.
2a	Opacity (brown) distinctly visible without air-drying.
3	Localised enamel breakdown in opaque or discoloured enamel and or greyish discolouration from the underlying dentine.
4	Cavitation in opaque or discoloured enamel exposing the dentine beneath

Table 1; The Ekstrand Index

We called the modified and adopted index The Clinical Severity Index (CSI). It had 5 groups;

The Clinical Severity Index (CSI), combined with treatment needs and protocols

CSI Index	DIAGNOdent Value	What you see	Extent of Caries	Assessed Treatment Needs	Tx with Ozone (sec)
5	> 30	visible on X-rays	3+ mm into dentine	<input type="checkbox"/> Lesion requiring drilling and filling <input type="checkbox"/> defined as deemed to have infected dentine where clinical infected demineralisation of the underlying dentine 3+ mm is deemed to be present. <input type="checkbox"/> Lesion may be cavitated.	60+seconds ozone

				<input type="checkbox"/> Open lesion, remove and soft debris to leathery layer. <input type="checkbox"/> Ozone treat, remineralising solution, FugiVII. <input type="checkbox"/> Review, re-assess mineralisation at 12 weeks <input type="checkbox"/> Restore if remineralised, repeat ozone if undecided	
3	25~29	? visible on X- rays	1-2mm into dentine	<input type="checkbox"/> Lesion requiring drilling and filling. <input type="checkbox"/> Define this as deemed to have infected dentine where clinical infected demineralisation of the underlying dentine= \leq 2mm is deemed to be present. <input type="checkbox"/> Lesion will appear frosted or white when dried. <input type="checkbox"/> Open lesion, remove any soft debris to leathery layer. <input type="checkbox"/> Ozone treat, remineralising solution, FugiVII. <input type="checkbox"/> Review, re-assess mineralisation at 12 weeks <input type="checkbox"/> Restore if remineralised, repeat ozone if undecided	60seconds ozone
2	20~24	stain	at the edj	<input type="checkbox"/> Lesion possibly requiring drilling and filling <input type="checkbox"/> Defined as possibly deemed to have infected dentine where clinical infected demineralisation of the underlying dentine is possibly considered to be present). <input type="checkbox"/> Lesion may appear frosted or white when dried. <input type="checkbox"/> Open lesion, remove any soft debris to leathery layer. <input type="checkbox"/> Ozone treat, remineralising solution, FugiVII. <input type="checkbox"/> Review, re-assess mineralisation at 12 weeks <input type="checkbox"/> Restore if remineralised, repeat ozone if undecided	40seconds ozone
1	10~19	white spot	confined to enamel	<input type="checkbox"/> Lesion requiring a pharmaceutical approach but <i>not</i> drilling and filling <input type="checkbox"/> Defined as deemed to have infected demineralised dentine which is reversing and getting	40seconds ozone

				<p>smaller. This scenario is where clinical remineralisation of the underlying dentine is considered to be in the process of remineralising the demineralised dentine but is not yet complete.</p> <ul style="list-style-type: none"> <input type="checkbox"/> Lesion may appear white or frosted when dried. <input type="checkbox"/> Remove superficial debris. <input type="checkbox"/> Ozone treat. <input type="checkbox"/> Remineralising solution, Restore. 	
0	< 10	n/a	n/a	<ul style="list-style-type: none"> <input type="checkbox"/> Lesion arrested <input type="checkbox"/> Defined as deemed to have had infected dentine which reversed and where clinical remineralisation of the underlying dentine is considered to be complete, with no infection remaining in the dentine. <input type="checkbox"/> The lesion is hard, shiny when dried. <input type="checkbox"/> Ozone treat for prevention. <input type="checkbox"/> Remineralising solution, Restore. 	30seconds ozone

Table 2; The Clinical Severity Index (CSI), combined with treatment needs and protocol

Amputating Tooth Tissue. At an early stage in their career and before entry into the dental profession, dental students are taught the Victorian principles of engineering; to amputate the diseased tissue from a tooth. As a slight digression, engineering principles state that foundations *have* to be placed on firm and secure foundations for the edifice to last. It is no different to any restoration placed in a tooth; any area of decay **not** amputated will lead to further decay, and the restoration will fail as the decay process undermines the integrity of the restoration. For the traditional approach to tissue amputation where infection exists, this is the **only** way to eradicate caries.

As a profession, dentists are taught to amputate the diseased tissue from a tooth, and they have a wide range of systems to help to do just that

The dental clinician has a wide range of systems to help us do so. We have the traditional turbine, diamond coated and carbide burs, ultra-sonic tips, air abrasion, and chemicals, such as Cari-Solv, to remove tooth tissue. All are very effective but they all amputate tooth tissue. In the first part of this article, I outlined the ozone research results produced by Professor Edward Lynch and his team at Queen’s University, Belfast, which showed that a single 10-second exposure to ozone gas deactivated 99% of bacteria, viruses and fungi in-vitro. When the bacteria involved in the carious lesion are exposed to ozone gas, the bacteria and their bio-molecules are oxidised to CO₂ and Acetate Acid. As the pH of the lesion is now altered from an acidic lesion to a basic lesion, the majority of lesions remineralise with just a single

60-second in-vivo ozone treatment.

As the acidic carious niche environment can take from 16 weeks to years to establish, it is unlikely that the niche will redevelop before remineralisation takes place. But how does this help us in practice, away from the research laboratories?

There are various dental ozone devices available (for example, the **HealOzone**, KaVo GmbH, **Ozi-cure**, O3 South Africa, **CMU3** and **CMU4** from Grey Cell Enterprises). These dental ozone units deliver ozone gas at pre-set concentrations, through a hose and hand piece that is placed in close proximity to the tooth surface requiring treatment. Each unit has its advantages and disadvantages. The HealOzone unit is aimed at just the dental market. In comparison, the CMU3 and CMU4 are aimed at a wider health-care market for the dental, medical and the veterinary market.

At the end of a 60-second to 10-minute ozone exposure, a mineral wash is placed over the treated area to kick-start the remineralisation process.

In just 40 seconds, ozone can eliminate the micro flora that cause decay and start the 'healing' process of a carious lesion
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So, in just 60 seconds on average, dentists can now, and very predictably, eliminate the micro flora that cause decay process and start the 'healing' process of a carious lesion. Once ozone treatment has been completed as necessary, the patient is sent away with an 'at-home care kit'. This consists of a dentifrice and remineralising mouth rinse, with patient information detailing the instructions they must follow for the treatment to be successful. This phase of oral hygiene instruction is an important part of the process. The reduction in fermentable carbohydrates, improved debris removal and diet, are all important keys to health, not just dental caries.

Follow-Up is Critical. The follow-up appointment for the larger lesion is critical to the success of this technology. The research team recalled patients at three- and six-month intervals to re-measure the treated lesions. Having cleaned the treated surfaces using the PROPHYflex, the initial data records and photographs are compared to the current records, using the CSI to record new values in the original data locations. To date, all results mirror those achieved by the research team in Belfast.

Patients are as astounded as is every practitioner who has bought into the ozone technology, to be part of the success of this painless technology. I am sure that, like myself, many of my colleagues who have attended the presentations are questioning when to use this technology and when to use a traditional filling. In my case, I have found that we no longer have to place any filling materials in the majority of lesions. I mentioned earlier that both patients and dentists have been pre-conditioned to restore a cavity when one is detected.

It has to be remembered that traditional means of caries elimination demands the amputation of diseased lesions. In most cases, it is impossible to define the exact limits of this, so we tend to remove far more tissue than is actually required. In so doing, we severely weaken the entire tooth structure, which could lead to catastrophic tooth failure and its eventual removal. Even if you use caries dyes, there is no indication of what tissue is soft, to that which can be

remineralised. Caries dyes only show the demineralised extent of the lesion. So even if you practice traditional amputation dental care, there is no indication of what is 'infected' as opposed to 'clean'.

Ozone eliminates 99% of the micro flora and so the decay process halts. Once remineralisation begins, the naturally restored tissue is far more resistant to decay. This has been shown in previous studies. We already know that it can take years for the niche environment to develop, so provided the patient's oral hygiene remains at an improved level, and the remineralisation process continues, there is no need to place any restoration at the first visit.

Average results with ozone in dental care

□ In the first study, we selected 82 surfaces with occlusal decay. Each was measured with the DIAGNOdent and the CSI following our protocol. The most common tooth that needed treatment was the upper right 7 molar. The most common start DIAGNOdent value was 85 and the most common finish value after treatment was 24. We saw most patients at a recall period of 64 days after the first ozone treatment and the most common change was 20 units.

□ In the second study, the average first value was 70 and the average second value was 15, giving an average 'healing' index of 55. On average, we saw patients 79 days after the first application of ozone.

As I have commented earlier, it is important to realise that the DIAGNOdent cannot give reliable values at follow-up appointments. The uptake of food stains will render the remineralised tissue as having a greater value than possibly at the pre-treatment value, returning a false positive. Various studies do show a reduced DIAGNOdent value after ozone treatment. This is to be expected, as ozone is an excellent oxidising agent - or put in a different way, this is the bleaching or whitening effect of ozone. However, in the clinical situation, we need to focus on the result at 2-3 months and thereafter, not the immediate effect of ozone, as the longevity of any restorative care is dependent on sound, remineralised tooth tissue.

One important factor that needs to be remembered is that during the initial stages, the treated areas of decay will be relatively soft and will not support any restoration. Therefore, if a restoration is planned after ozone treatment, it should be planned at the review appointment at 2-3 months after the initial ozone treatment by which time, the research data suggests, the remineralisation process will be well advanced, the lesion static and reversed, and the tissue hard enough to support a transitional restoration.

A waiting time of three months or more may decrease the amount of tooth tissue that may have to be removed to obtain a cosmetic result. This, in turn, preserves as much of the original tooth as possible. Lastly, studies have shown that if the lesion is left open - a strange concept for both the patient and the clinician - the remineralisation occurs in about 6-8 weeks. In this situation, clearly improved oral hygiene and the use of remineralising washes will hasten the 'healing' effect. If a logical approach is taken to the remineralisation of lesions once 'sterilised' by ozone, then the patient's own saliva is the best mineral source. The remineralisation effect can be improved by the use of a remineralising mouth wash and tooth paste to increase the bio-availability of minerals such as calcium, phosphate, and fluoride.

One promising area of research is the caesin proteins from dairy products. GC launched

'Tooth Moose'. Tooth Moose releases minerals in both acidic and basic conditions, so forms the perfect base for remineralisation. A potential for development would be the incorporation of the caesin protein release system, with Fuji VII. This would combine the 'smart' filling technology with the mineral release during all phases of oral pH change.

Where a transitional filling is placed, the 'healing' time is longer - 3 months. It is suggested that remineralisation in this situation occurs from the pulp tissue and not from the oral cavity fluids. This has been observed by many of the pathfinder group members, and their x-rays suggest this is an area for further research.

Technology Presentation. One question that all of our patients ask, once we have identified and measured an area of decay, is 'when do I get a filling?' When ozone technologies are used to treat areas of decay in tooth structure - "caries" to the dental practitioner, "decay" to the public - I believe that it is *not* necessary to fill teeth unless there is a requirement to replace lost function or support. This conceptual barrier needs to be overcome by dentists attending presentations on ozone technologies; this concept is also very difficult for patients to understand. The common belief is still that decay found equals filling required. As a dental practitioner myself, we are conditioned from the start of our clinical training that *any* of decay must be treated by amputation and then restored. And we have reiterated this concept every day that we practice - until we read an article or attend a presentation that is, literally, a revolution in dental practice.

...fillings in the traditional sense are not necessary any longer. This concept is difficult for dentists and patients to understand. The common belief is and practitioners are conditioned that *any* decay must be amputated.

Once we begin to explain why a traditional approach and filling is no longer required, people's first reaction is to ask why not all dental practices have this technology. That is probably one of the most difficult questions to answer truthfully! There is no reason why every practitioner should not be aware of the new technologies; neither why all patients should not be potential candidates for ozone therapy.

So how do we present ozone technologies to the general public - the dental profession's patients? We have produced an information brochure that outlines the system, the benefits and the costs compared with a standard single surface filling. This brochure answers many of the main questions raised by our patients in simple terms, such as:

- 1. What is ozone? Ozone is a special gas that our dental ozone unit makes to kill the bacteria that are causing decay in your teeth.
- 2. What can ozone do for me? Ozone can stop the decay process in a simple, quick and painless process. It takes from just 40 seconds.
- 3. How do I know it has worked? In three months time, we will ask you to return to evaluate your teeth. In most cases, the decay will have halted or reversed
- 4. Will I feel anything? No! The process is quick and simple, and you will not feel anything.

□ 5. What are my alternatives to ozone? We can place a traditional filling by amputating part of your tooth, placing a filling that will probably fail at some time in the future. You will enter into a cycle of destruction that will probably result in the eventual loss of your tooth.

Some practices charge from £15 - £30 UK Pounds for every ozone treatment, and then charged an additional fee for the filling material used. One government-funded/socialised care practice in Ireland charged £5.00 for every ozone treatment, on the basis that it would save the practice larger sums, in terms of reduced time, reduced re-current decay and fillings, and post-operative pain appointments.

We promoted ozone treatment to our patients because :

- It allows natural remineralisation of decayed tooth tissue *without* the need for, in most cases, an injection, drilling or filling
- This quick, non-invasive, instant bacterial elimination is painless and so less traumatic for the patient.

One additional question my team was asked by a caller to the practice was: 'How were we taking ozone out of the sky to treat teeth, and was there less now to protect him?' This question reflects how much education we as a profession will be involved in when we take up this new technology. The uptake of this treatment has exceeded all expectations and this has been reflected by every dental practice across the world that has invested in this technology. Our information leaflet has been based on those questions asked by our patients and the dental team. As modern technology allows all brochures to be produced in-house, they can evolve as necessary. By pricing the treatment below the cost of a traditional filling, there is a positive pressure on the patient to take up this treatment modality. And lastly, as one of the first dental practices to offer this technology, we had a positive marketing tool to use in attracting new patients.

When we started to audit where and how patients found our dental practice, the www accounted for over 85% of all new patients, and articles posted on our www site 'pulled' the patient in. The www remains a very cheap but powerful marketing tool. The information that you have in your practice should be reflective of *your* practice - not anyone else's! It may seem a simple point, but if you cannot deliver what you have printed, then you will lose your patients just as fast as they found you. Keep your message short and simple. If you cannot copy write, then approach your patients - you do of course make a note of what jobs they do, don't you? Failing your own client base, then look outside into the commercial world. Social networks like Facebook and Twitter are also very effective marketing tools.

I see that The GDC has at last got around to issuing rules on the use of these media, so I strongly suggest every dental practitioner in the UK makes sure they are aware of these guidelines, and makes sure that their www sites follow them.

Research and Support. One aspect of buying into a new technology is always whether there is adequate support for it, service backup, product information and clinical technique clarification if required.

For CMU3 and CMU4 current costs, delivery, service, parts and general information from O Grey Cell Enterprises, please contact Dr Julian Holmes. The Clinical Protocols are available

from GCE.

The www still remains the best source of information, with a user-group and information being available through www.the-o-zone.cc. The user group is international and has some 1000 dentists, doctors and vets around the world who pool their information and experiences. The www site is closed to the general public, as it is intended as a forum for clinical practitioners to talk freely about ozone treatment.

As the number of practices buying into this technology has increased, many of the frequently asked questions covering all areas of the use and promotion of this product have been collated into a readily accessible database for general release to users. This [FAQ Sheet](#) is included in this publication.

...every practitioner has a strict duty of care and should rethink their management caries in the light of the current published research

The use of ozone to treat dental decay and its other uses in everyday dentistry is not without controversy. The Cochrane Group have published several papers where they questioned the research, and questioned the use of ozone. Later papers that used these reports as their basis went so far as to suggest that ozone was a myth and could not be recommended. In the defence of ozone I can say that in all my years as a clinical dentist, I – and many others around the world – have never seen such good results from a new technology. As a lecturer, I get to hear about the successes and the failures. The failures are far more important than the successes, and the vast majority of failures are due to non-compliance with the treatment protocols. The rest are usually due to poor initial diagnostics or equipment failure.

In parts of Europe and in Cuba, ozone-treated liquids are used as modern anti-biotics, anti-fungal and anti-viral agents. The research into these products is not recent – in some cases, the research dates from the 1800's. I will be exploring the use of these liquids in the next article, as for the majority of procedures where the dental profession issues scripts for infection, there is a holistic and non-resistant alternative. To date, bacterial, fungal or viral resistance to ozone has never been reported.

In this article, I have tried to show how dental care is changing. There is a real need for practitioners to change their practice of dental care. As ozone technology becomes a topic of interest in the national and international media, patients will start to ask their dentist about this technology and may demand it. The scientific research shows that the technology is effective and that the mindset of 'amputation of tooth tissue' has to change.

Every practitioner has a strict duty of care and should therefore rethink their detection and management of infection in the light of the current published research.