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Features.

ISSN 2399-1534
ISSUE 107



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Shedding fresh light on dental demineralisation

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Teeth are made up of a central core containing blood vessels and nerves, surrounded by a relatively soft matrix known as pulp. This is, in turn, surrounded by a layer of dentine and the whole tooth is covered in a hard enamel surface to protect it from damage. This enamel is the hardest substance in the human body – but, despite this, is still prone to a process called demineralisation.¹

A DENTAL DISASTER

Several processes are responsible for demineralisation, from purely physical erosion (e.g., grinding) to chemical erosion in the form of acid attack. Acid enters the mouth from foodstuffs such as fizzy drinks, stomach acid in severe acid reflux, or more commonly as a by-product of bacterial respiration.

Bacteria are naturally present in the mouth, in fact some of them are beneficial. However, others actively attack the enamel of teeth and promote demineralisation. The most damaging of these are encouraged to proliferate by excess sugar in the diet, forming bacterial plaques under which the acid is trapped against the vulnerable enamel.

ALL PAIN AND NO GAIN

More than 30% of the UK population suffer from dental caries², where the enamel of the tooth has been weakened due to demineralisation. Left untreated, or spotted too late, it can result in the cavitation of the tooth and exposure of the sensitive inner structure. This then requires drilling (to enlarge the hole back to solid enamel) and filling (with a suitable composite material).

Demineralisation and remineralisation (the natural repair process) of the teeth is a dynamic process, occurring constantly in a healthy oral environment. It is up to dental practitioners to spot when insufficient remineralisation results in a net loss of minerals on the tooth surface³ and then provide appropriate treatment to counteract its effects. Until recently, this has relied on visual and tactile inspection of the tooth surface – with dentists using their knowledge and experience to identify active caries sites over inactive ones. The unfortunate result of this, however, is that some cases go untreated before it is too late, while others are treated unnecessarily.

ILLUMINATING INSPIRATION

Chris Longbottom from King's College

Dental Institute is a paediatric cariologist and one of the inventors behind the CALCIVIS technology. He says, "The initial idea for what would eventually become the CALCIVIS imaging system came to me whilst I was attending the International Association of Dental Research meeting in Baltimore."

It was not a particular speaker that inspired him though. Instead, browsing a bookshop during a slow afternoon session he picked up a book about bioluminescence in marine organisms and noted that the process was regulated by minerals such as calcium ions. This sparked the idea for a novel way to image active caries in teeth – and the concept of CALCIVIS was born.

With help from Adam Christie, an experienced business developer in the pharmaceutical and biotechnology markets, they set about developing the initial products, although it was not until Bruce Vernon came on board that the technical difficulties around imaging were resolved. Bruce has extensive experience of immunological techniques as well as regulated manufacturing facilities, so he was well placed to bring the technology from concept to realisation.

LET THERE BE LIGHT

At the heart of the CALCIVIS imaging system is the CALCIVIS photoprotein – a dental biologic which produces light when it reacts with the free calcium ions which are released on actively demineralising tooth surfaces. Because these small flashes of light are not visible to the naked eye, the CALCIVIS system also comprises a specialist imaging device designed exclusively to image the tooth surface after delivering a metered volume of CALCIVIS photoprotein.

Using a one-touch, computer-controlled process, the bespoke software presents a chair-side demineralisation "hot-spot" image-map to clinicians in less than a second, enabling an informed and efficient dialogue with patients right there in the clinic. It is this immediate access to accurate, objective information about the patient's risk of developing caries or erosive lesions which means the technology is a benefit to preventive dental care.

ROLLING OUT TO PATIENTS

Armed with the information the imaging system provides, a dental practitioner can target specific areas for treatment, as well as engage the patient in a visual demonstration ▶

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The clear display (above) and the spectrum used in the CALCIVIS images (right) simplify discussion and interpretation – the lighter colours indicate a more severe lesion

of how their oral hygiene behaviours affect their teeth. By moderating their diet or using specific treatments on teeth with early-stage, active lesions, the patients have a good chance of stopping demineralisation in its tracks, preventing painful cavitation and subsequent restoration of the teeth.

With the vital patient safety tests already completed in the UK and progressing in the US, CALCIVIS is set to bring its product to market with a launch in the UK in 2017. Following successful trials in four dental clinics in Scotland, the Principal Investigator, Charles Ormond, said, "It has been very interesting to be involved with a clinical study of this new technology in Scotland. The images have the potential to provide real insights into the ongoing demineralisation disease process". This enthusiasm for the technology is indicative of the likely response from other clinicians.

CALCIVIS CAPTURES THE MARKET

Exhibiting at dental and biotechnology fairs and congresses around the world, the aim is

CALCIVIS provides an immediate view of oral health in an easy to understand format – patients can leave the clinic knowing exactly what they must do to prevent dental demineralisation and caries developing

now to publicise the new technology as widely as possible to encourage uptake. Costing only a few pounds per patient in consumables and with low capital outlay, this technology is set for rapid uptake in the private dental care market. With the focus here on preventive treatment to reduce costly interventions, CALCIVIS gives clinicians an indispensable tool with which to help and educate patients whilst, at the same time, providing vital data to the professionals.

It is just as positive from the patient's point of view. CALCIVIS provides an immediate view of their oral health in an easy-to-understand format. They can leave the clinic knowing exactly what they must do to prevent caries or erosion progressing and adjust their lifestyle accordingly. Return visits will be to monitor the situation accurately, rather than for the dreaded drill and fill, meaning a much-improved patient-clinician relationship.

Q&A

How does demineralisation occur and why is it such a problem?

Fundamentally, demineralisation starts with the dissolution of tooth enamel, either through physical erosion or acid attack. This means you start to lose calcium ions. We're able to detect those calcium ions and visualise them. So, CALCIVIS' technology is the most direct measure you can get of active demineralisation. And, if you think about it, demineralisation is at the root of all dentistry. If teeth were inert and not subject to demineralisation related to acidic conditions, then you wouldn't need much of modern dentistry.

Why are current solutions less than ideal?

Currently, the search for or assessment of early demineralisation in particular, is predominantly a visual and tactile process. Dentists use a rounded probe called an 'explorer' to test the firmness of the tooth's surface. It's quite difficult to see early lesions, and when you do see them it's even more difficult to understand whether they're actively progressing or not. So there's a significant level of subjectivity in the diagnostic workup for early caries lesions, and for acid erosion as well. What we're doing at CALCIVIS is giving dentists a tool that enables them to see active demineralisation and to know whether or not it's actively progressing.

How does CALCIVIS image demineralisation – what would the dentist and patient experience of the imaging process be?

For the patient, it would feel like the dentist was using a standard intraoral camera. These are specialised cameras adapted for the oral environment, and in our case a dentist uses a video feed to identify the tooth of interest. Essentially, the dentist then simply pushes the button on the device, and within less than half a second the device has both sprayed the protein onto the tooth surface and imaged the tooth. That image is then instantly available on the screen. And the nice thing about our images is that they are very straightforward to interpret: at the heart of the technology is a photoprotein that reacts with calcium ions, and the higher



Detail

RESEARCH OBJECTIVES

CALCIVIS are focused on revolutionising the management of dental demineralisation by providing real-time chair-side assessment of the caries and erosion process.

FUNDING

Archangels Investors Limited
Scottish Investment Bank
European Union's Horizon 2020 research and innovation programme
Innovate UK Biomedical Catalyst

BIO

CALCIVIS was co-founded in 2012 by Adam Christie and Bruce Vernon. The CALCIVIS imaging system was developed with input from Professor Nigel Pitts and Dr Christopher Longbottom – both leading specialists in dental caries management, based at King's College Dental Institute.

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CALCIVIS
dental enlightenment

the concentration of calcium ions in the lesion, then the more luminescence we get – we use a royal blue spectrum as an indicator which goes from very dark blue through to white, indicating the concentration of calcium ions. If you compare this to the interpretation of x-ray images, for example, it is very straightforward – you can tell how severe the lesion is from the colour whereas a 3D x-ray image requires a lot of skill to interpret.

The image is then displayed and the dentist can directly show a patient where the tooth is demineralising, where calcium is being lost from the tooth. We know from the clinical studies that we've been doing, that patients actually like to see this. It's a revelation to them, particularly when the dentist explains that they can use a preventive therapy to stop any further demineralisation, which in turn stops them getting a cavity and stops the dreaded drill and fill.

What are the principal benefits of the CALCIVIS system?

Some of the market research we've done with dentists has suggested that using CALCIVIS would change two things about their management of patients. First is that there would be significantly more communication with the patient: if you have a relatively straightforward image that you can discuss with the patient in a way that is easy for them to understand then the level and quality of the communication goes up. Second is that dentists have said they would use preventive products significantly more as a result of using the technology. Importantly, they know that there's an issue that needs to be addressed – there's active demineralisation. There are a number of products out there, like fluoride varnishes, various remineralisation agents, sealants, etc. that can be used to arrest demineralisation or actually reverse it.

The key thing, though, is they can then monitor the effectiveness of the treatment, because one of the difficulties with these remineralisation therapies is knowing what the optimum treatment regime is and knowing whether you've treated the patient successfully or not. If you've remineralised that lesion or you've stopped any further

demineralisation, our technology can show that and again that's something that dentists haven't had before.

Dentistry is gradually shifting. In the old days, we had the drill–fill paradigm, where even with relatively early lesions you'd often end up having a restoration. Now, there is a gradual move towards a more diagnostic workup, and more focus on prevention and the use of these secondary preventive products. At CALCIVIS, we aim to enable that preventive paradigm. That's what the technology is all about as far as we're concerned. So that is the main benefit and that's a significant benefit in terms of dentistry, but also for patients themselves.

What are the next steps for bringing CALCIVIS to market?

We're just about to start a beta test in the UK with 20 practices who are going to install the product and use it in a normal routine clinical setting. This allows us to do things like software refinements, and so on and so forth, just to see how the product behaves in a normal routine clinical environment. That beta test will allow us to make any final tweaks and so on, before we formally launch the product in the UK later on this year. We're also preparing to make our regulatory filing in the US so we could potentially be in the US market before the end of next year.

We've been meeting with most of the big dental companies this year, and I think people are impressed with the progress that we've made, because just four and a half years ago this was essentially just an idea. We've really had to develop it from scratch so I think we've done quite a lot over that period of time.

1 Ross, M., Kaye, G., Pawlina, W. (2006) Histology: a text and atlas, 5th ed., Philadelphia; London; Lippincott Williams & Wilkins

2 Oral Health Foundation: National Smile Month, Facts and Figures. Link: <http://www.nationalsmilemonth.org/facts-figures/> [accessed 06/04/17]

3 Featherstone JD. The continuum of dental caries-evidence for a dynamic disease process. J Dent Res.2004;83 (special No C):C39–42. [PubMed]





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