OCCUITY TECHNOLOGY

Diabetes Screening

Diabetes is a life-long, life-threatening disease caused by the body's inability to produce or effectively use insulin. As a result, the body cannot adequately regulate its blood glucose levels. Diabetes has no known cure.

The scale of the diabetes problem is such that it is now being described as a pandemic and in the UK alone there are 4.7 million people suffering from the condition. But that headline ignores one aspect of the problem that isn't getting the attention it deserves. Of that 4.7 million there are 900,000 people with diabetes that haven't been diagnosed and a further third of all adults – almost 17 million people - who have pre-diabetes and are very likely to go on to develop full diabetes within 10 years.

There is therefore a desperate need for a convenient way to screen for diabetes and pre-diabetes. Unfortunately, this currently requires an inconvenient blood test so can only be performed in a clinical setting. Those who don't know or suspect they have diabetes or pre-diabetes don't present themselves for these tests.

As the diabetes problem is growing rapidly, at around 10% per year, so is the cost to the health service. The NHS spends £14bn every year treating diabetes and its complications. Without screening and lifestyle changes 70% of the people with pre-diabetes will develop full diabetes at an approximate additional cost of £49 billion per year. If regular screening can prevent 10% of these from developing diabetes that will lead to a saving of £4.9 billion each year. The potential cost savings of screening for diabetes are therefore remarkable and will influence government priorities.

The Occuity team has developed an optical confocal scanning technology that can detect the concentration of Advanced Glycation End-Products (AGEs) within the eye. This measurement can assess the risk of whether a person has, or is likely to develop diabetes. Blue light illuminates the eye and the returning scattered blue light and the green fluorescent light from the AGEs is detected. The test is completely non-contacting so can be performed in a non-clinical setting in a GPs surgery, a pharmacy, an optician's practice or even in a domiciliary care setting.

Such a screening meter provides the opportunity to generate significant levels of patient health data. Measurements taken at regular intervals, over a long period of time, could be used to assess the rate of progress of the disease and therefore the effectiveness of any treatment. In addition, the data collected could be processed using machine learning algorithms to create a population database of the diabetes problem. This would enable well informed diabetes healthcare programs that ensure that limited budgets are targeted as effectively as possible.

Glucose Monitoring for Diabetics

In an attempt to maintain blood glucose levels within the normal range, patients with diabetes must first measure those blood glucose levels. Often after making the measurement the patient is required to make therapeutic adjustments. As adjustments are made, additional measurements may be necessary to gauge the individual's response to the adjustments. More frequent testing therefore provides patients with information that can be used to better understand and manage their diabetes. It is often recommended that patients perform glucose tests at least three or four times

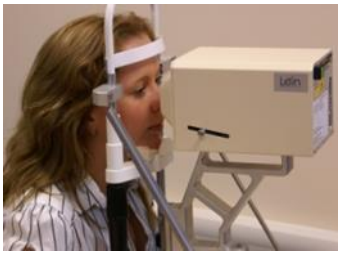
per day because clinical outcomes data support the notion that an important component of effective diabetes management is frequent monitoring of blood glucose levels.

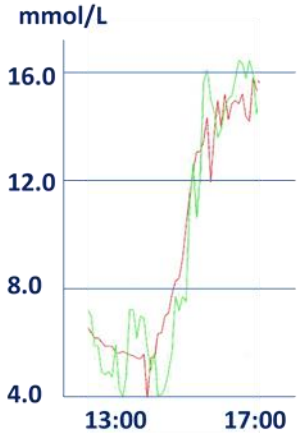
The current 'finger stick' method of measuring blood glucose is a multi-step process that is particularly difficult for young and elderly patients, or those with impaired vision or motor control. The user pierces the skin in the fingertip with a lancet to draw blood, applies the blood to a test strip and then reads the glucose value on the meter. This process is painful, risks infection, can damage nerves and is unpopular, especially with young children and teenagers. Although widely disliked the need for regular testing has generated a market for the test strips that is currently worth in excess of $14bn. The strong demand for a pain-free method of glucose monitoring combined with the size of this market makes it an exceedingly attractive opportunity.

The Occuity glucose monitor

Occuity's solution will be a mobile phone sized meter that the user simply looks into, presses a button and a reading is taken from the eye. From the patient's point of view this will overcome the problems associated with finger stick testing, from the clinical care point of view the patient will test more often and so will suffer less from the problems associated with diabetes and from the health service point of view the cost of testing will be reduced.

The Occuity team has built a number of non-invasive glucose meter prototypes and used these to demonstrate the feasibility of measuring glucose via the eye. As part of initial clinical trials, dedicated meters were developed purely to collect data and so were large units built onto ophthalmic stages. Miniature demonstrators have been developed that contain the functional measurement technology and are roughly the size of a TV remote control. The roadmap for further miniaturisation to a pocket-sized device is well understood.





The Clinical trials were conducted on volunteers with both Type 1 and Type 2 diabetes. In a study on 30 Type 2 volunteers at the Royal Berkshire Hospital a strong correlation (p-value of less than 0.0001) was seen between the volunteers' eye and their blood glucose level. In another study, on five Type 1 volunteers, it was possible to calibrate the meter to an individual then, when data was collected on a new day, estimate the subject's blood glucose level from just their eye data.

In the figure to the left the red trace is the actual blood glucose level and the green the estimate calculated from the eye data. It can be seen that there is a very positive correlation between the gold standard blood based measurement and the measurement given by the Occuity device. The ISO requirement (ISO 15197: 2013) is that the meter should give a result within 15% of the gold standard value 95% of the time (it is slightly more complex than this but that is the broad goal).

Although the quality of the blood glucose readings obtained from these clinical trials has demonstrated that a good correlation is possible, the current clinical data is not of a sufficient

standard to consistently meet the regulatory requirements – the data is simply too noisy. The next stage goal is therefore to further develop the meters so that their alignment to the eye is more accurate and consistent, their data collection and handling is such that no noise is added to the data and their processing and analysis gives the quality of data output required to confirm consistent correlation. The advances in the Occuity pachymeter technology combined with a recently tested complementary optical technique (giving a more direct measurement of certain areas of the eye) provide the necessary improvements to the current device to solve the noise issues and therefore render an accurate measure of the blood glucose level of the patient that correlates closely with the gold standard blood test.

It is estimated that this technical development, including the regulatory approval necessary to put these meters into clinical trials, will take approximately one year.

Once these new, more advanced meters are complete they will be put into thorough detailed clinical trials. These trials will be on Type 1 diabetic volunteers and will compare the performance of the new non-invasive meter to a gold standard venous blood glucose meter. Obtaining ethics approval, collecting the clinical data and performing the analysis will take a year.

Building on this successful proof point it will be necessary to conduct large scale clinical trials to build the body of data necessary for CE marking. Due to the scale of testing required, it is estimated that the building of the large number of trials meters and the collection of the clinical data will take approximately two years.