FAECAL PELLET SENSOR

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Defaecation is a complex process that utilises chemical signals to drive a coordinated series of muscle contractions and relaxations to expel faecal matter. To date this process is not fully understood and therefore understanding how these processes change over time and how they lead to dysfunction are limited. At present no technologies exist that can fully understand how faecal matter within the rectum directs relaxation of the internal anal sphincter leading to coordinated defaecation. The goal of this research was to develop a sensor shaped like a faecal pellet. By mimicking faecal matter in this way the device will stretch the inner lining of the rectum to direct the opening of the anal sphincter to expel waste and could then simultaneously monitor the complex combination of mucosal signalling and muscular contractions that occur during the process of defaecation.

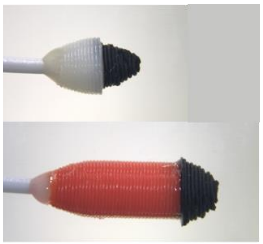

Figure 1. Final 3D printed devices

This study, led by Dr Bhavik Patel, focused initially on the development of sensor devices that could be used for both measurement of bowel chemicals and the movements of the bowel that play a key role in holding and expelling faeces. The device was developed using 3D printing whereby the conductive materials were formed into the shape and size of faecal matter (Fig.1). Using this approach saved production time and meant that that researchers could make devices suitable for various animal trials which could eventually be simply scaled up to deliver a prototype capable for use in humans.

The device was tested to see if it was capable of measuring chemicals released within the bowel and if it could react to monitor the movements of the bowel. The sensor was shown to respond to the amounts of the bowel chemical serotonin shown to be present in the bowel from previous studies and tests confirmed that it was able to provide stable measurements for 20 minutes. An experimental set-up that would mimic the bowel was used to understand the sensor's capability to respond to muscle movements of the bowel. Simple plastic tubing was used and the device placed within it before gently squeezing the tubing using a set of tweezers in a similar way to the mechanism that would occur naturally in the bowel (Fig. 2). The sensor was shown to respond as the response was significantly different to that observed when changes in the bowel chemicals occurred.

These combined characterisation studies suggested that the device was capable of measuring both bowel chemicals and muscle movements within bowel tissue so to validate this the research team conducted measurements in the bowel of an animal model. The sensor was inserted into the rectum to anus region and a drug was used to alter the levels of luminal serotonin. The bowel was monitored for contractions using a force transducer and responses could be seen in the device similar to those observed on the force transducer. Similarly the sensor's response to changes in luminal serotonin mimicked the changes induced by the addition of the drug.

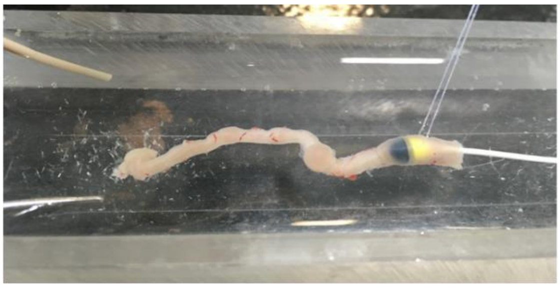

Figure 2. Experimental set up using device placed in the rectum region with force transducer attached for monitoring muscle contraction

Overall the concept of a faecal sensor for measurement of muscle tones and signalling molecules was achieved, however further work is needed to understand how changes to the device can provide enhanced sensitivity and under which conditions it is best to use the device. Once these challenges have been met a study to show the suitability of the device for identification of incontinence will be conducted. This IMPRESSplus 2016 funding in tandem with an IMPRESS Knowledge Exchange Award granted in 2017 has given the researchers the opportunity to work with Prof Gary Mawe at the University of Vermont who is regarded in the research community as a leading expert in bowel inflammation and serotonin. Investigations in his research group using these devices will provide significant validation and high level understanding of the capabilities of the faecal pellet sensor.

To achieve its ultimate goal of creating a device suitable for use in humans, in the short term Dr Patel and his research team plan to apply to the Biotechnology and Biological Sciences Research Council for next step funding for work to enhance the sensitivity of the device and study the changes in muscle dynamics and luminal signalling that result with ageing. In the longer term they aim to collaborate with an industry partner to develop a wireless prototype which would be an essential element of a device for human use.