Electrical impedance spectroscopy-based oral cancer diagnosis using tissue engineering and computational models

Malwina Matella, Rachel Furmidge, Zhicheng Lin, Helen Colley, Craig Murdoch, Zi-Qiang Lang, Dawn Walker
University of Sheffield, School of Computer Science
Abstract:
In 2024, there were 11,000 new cases and almost 4,000 deaths, associated with oral cancer in the UK [1]. The current oral cancer diagnosis involves a visual inspection of the lesion, followed by a biopsy - a painful and expensive procedure, with long turnaround times. Electrical impedance spectroscopy (EIS) is an emerging technology permitting a non-invasive and real-time identification of cancerous changes in various organs (such as cervical epithelium, skin or breast tissue) based on the influence of cellular level tissue structure on the opposition to the flow of an alternating electrical current. Oral tissues are more varied in nature than these other tissue types, which may pose a challenge in the application of EIS to oral cancer detection.
In a pilot study, we aim to explore the feasibility of EIS measurement to enhance the diagnosis of oral cancer. To achieve this, we cultivate tissue-engineered models of healthy and cancerous oral epithelium and measure their electrical impedance using a tetrapolar EIS device. Histology images provide morphological information on the micro- (cell sizes) and macroscale (epithelium layer thicknesses) of these tissues. These are used to develop virtual tissue constructs to simulate the expected EIS measurements using finite element (FE) methods, to further broaden the understanding of the relationship between the tissue structure and their electrical properties in healthy and cancerous tissue.
Comparison of the preliminary in vitro EIS measurements and computed impedance from the virtual tissue constructs revealed a promising agreement, in terms of characteristics of the real and imaginary components of impedance spectra in the healthy and cancerous oral epithelia. In the future work, we plan to validate the FE model to use it to augment the in vitro measured EIS sample size to develop a machine learning algorithm to differentiate between cancerous and non-cancerous tissues, based on EIS measurements.
[1] State of Mouth Cancer, UK Report 2024, https://eur03.safelinks.protection.outlook.com/?url=https%3A%2F%2Fwww.dentalhealth.org%2FHandlers%2FDownload.ashx%3FIDMF%3D6531c6d5-2651-46cf-9d4d-063d73b1fc8e&data=05%7C02%7CGillian.Brown%40glasgow.ac.uk%7Cd95c759132174cab04c008dd446bad57%7C6e725c29763a4f5081f22e254f0133c8%7C1%7C0%7C638741951452638567%7CUnknown%7CTWFpbGZsb3d8eyJFbXB0eU1hcGkiOnRydWUsIlYiOiIwLjAuMDAwMCIsIlAiOiJXaW4zMiIsIkFOIjoiTWFpbCIsIldUIjoyfQ%3D%3D%7C0%7C%7C%7C&sdata=VTDs0i0uAkHKNZeAVdK4H6RbCBH4kk%2Bs8B5A5rdUVpk%3D&reserved=0, Retrieved January 2025.