Abstract

The loss of central vision due to the occurrence of a macular hole in an eye is an alarming and serious condition that occurs quite frequently in people over the age of 55. Predicting the visual acuity of the patient after macular hole surgery (vitrectomy) and managing their expectations is a difficult task for the ophthalmologist as there are still many unknowns. Spectral-domain (SD) optical coherence tomography (OCT) imaging allows ophthalmologists to diagnose, classify and measure MHs. This project seeks to use novel AI methods on pre-operative OCT scans together with post-operative visual acuities to predict outcomes more accurately and thus help ophthalmologists manage and advise their patients on eventual visual acuity outcomes.

Introduction

Idiopathic full-thickness macular holes (MHs) form secondary to age-related abnormalities of the vitreoretinal interface with a prevalence of up to 3 in 1000 people over the age of 55. They appear as a small dehiscence in the neurosensory retina at the centre of the fovea, a highly specialised part of the human retina responsible for fine acuity and colour vision. Spectral-domain (SD) optical coherence tomography (OCT) imaging allows ophthalmologists to diagnose, classify and measure MHs. OCT is a non-invasive, high-resolution imaging technique that uses infrared light to image the retina in 3D. Macular holes can be effectively treated by closing the hole using vitrectomy surgery. They are one of the commonest indications for vitrectomy surgery accounting for ~4000 surgeries in UK and more than 200,000 globally per annum. Predicting the visual outcome after surgery is important to guide the decision to operate and manage patients' expectations, as well providing insight into their pathology. Several studies have shown that postoperative visual acuity (VA) is correlated with a variety of measures of macular hole size that can be measured on SD-OCT. Various studies have attempted to precisely predict postoperative VA using manual 2D measurements of MHs and preoperative VA, although their predictive ability has been limited. Three-dimensional automated image reconstruction has improved this ability, but there are no current standards for shape, size, and resolution of OCT imaging data captured by different OCT devices for this task.

Research Challenge

Most existing machine learning (ML) and deep learning (DL) approaches have focused on the automated classification of macular diseases, such as age-related macular degeneration (AMD), diabetic macular oedema (DME), and MHs from OCT images data. More recently, some DL approaches have attempted to improve the prediction of VA outcomes using OCT data although these have been very limited and mainly in diseases other than MH.
This project will try novel ML/DL approaches on OCT scans, guided by expert clinical knowledge, to improve the prediction of VA outcome for patients.

Data & Methodology

Preoperative OCT scans have been collected already together with post-operative visual acuities of patients. After the usual image and data preparation, the OCT scans would be analysed using a variety of ML/DL methods with Python programming.
Our external NHS Consultant Ophthalmologist is experienced in research methods and has ideas of fresh lines of investigation for this problem building on the latest from his research group (https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=10445126).
RRI/Ethical Considerations
The images and patient VA outcomes were all collected during routine NHS treatment or according to ethical rules in other countries and are anonymised.
Expected Outcome & Impact
It is expected that new and better AI methods would be found to predict post-operative visual

acuities. These would be disseminated in papers and at ophthalmological conferences to inform clinicians when discussing macular hole surgery and the possible outcomes with patients.