Small-Separation Speckle Contrast Optical Spectroscopy for Intraoperative Assessment of Parathyroid Glands Viability during Thyroid Surgery

Connor Berger

Small-Separation Speckle Contrast Optical Spectroscopy for Intraoperative Assessment of Parathyroid Glands Viability during Thyroid Surgery

The parathyroid glands (PTGs) are often damaged during thyroid surgeries due to a lack of methods identifying PTGs and assessing their viability. Damages to PTGs can cause hypocalcemia, a deficiency of calcium in the body. This complication can lead to detrimental consequences with economic burden. The surgeon's current method of viability determination is a visual assessment, which is qualitative and subjective. Our technical solution is to employ an optical technique called speckle contrast optical spectroscopy (SCOS) that noninvasively quantifies the blood flow index (Db) of biological tissues at deep tissue levels (>1cm). The goal of this project is to verify SCOS at small source-detector-separation (SDS) distances (<1cm) suitable to PTG size.

First, using an analytical model, we have observed a linear relationship between (Db) vs. 1/K2 (K=speckle contrast) that has been verified in SCOS measurements at larger separation distances. To computationally verify the principle of small-separation SCOS, we have implemented the inverse model to estimate Db from the simulated speckle contrast data with multiple exposure times. For experimental verification, we have set up a bench-top SCOS system consisting of a long-coherence-length 785nm laser and scientific CMOS camera as a detector with SDS=2mm. The team measured K for 100 speckle images at different temperatures (C), using a 5ms exposure time, to observe change in speckle contrast as temperatures increase.

The analytical forward model shows that 1/K^2 is linearly proportional to Db at different source-detector separations. Initial experimental data also supports that 1/K^2 is proportional to the flow rate of the phantoms, showing positively increasing trend of lower speckle contrasts as temperatures increase. Experimental verification on flow phantom is ongoing. The next step is to apply the inverse model to the speckle image data gathered from flow phantom.