Improving Intraoperative Laser Speckle Contrast Imaging Hardware via Ray Optics Simulations

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Introduction: Monitoring cerebral blood flow during neurosurgery is essential to guide the surgeon in his procedure and reduce the risk of complications and additional hospitalization costs. However, there currently is a lack of real time, continuous and agentless imaging modality to monitor cerebral blood flow intraoperatively. An emerging method of intraoperative imaging, Laser Speckle Contrast Imaging (LSCI), has the potential to provide to fill this gap. Richards et al. successfully integrated LSCI on a surgical microscope[1] using a custom-built detection piece and laser illumination piece as shown in Figure 1.a. However, the current laser illumination piece used by Richards, requires redesign to reduce its weight and improve the overall light throughput which would considerably improve the LSCI images acquired.

Materials and Methods: To help optimize the laser illumination piece into a more optimal weight and maximize the light throughput, we used *3DOPtix* ray optics simulation software to better understand the light path shown in *Fig 1.b*. First, we used the laser function of the simulator to truly understand the path of the coherent light through the current laser illumination piece. As within the *3DOPtix* program, we reproduced the laser illumination piece with accurate distances between the convex mirror, 785 nm laser diode, and custom designed lenses based on measurements taken of the actual laser illumination piece. Thus, we propagated a simulation of the path of the laser rays through the laser illumination piece.

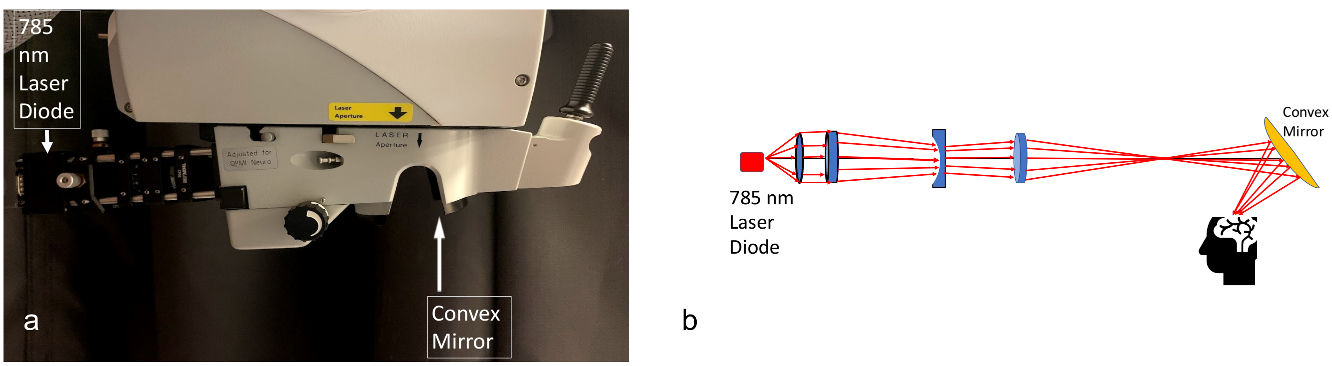

Fig 1. Intraoperative LSCI laser illumination piece. (a) The hardware designed by Richards et al. connected to the head of a surgical microscope and (b) its associated hand-made optical diagram.

Results and Discussion: The *3DOptx based* simulations will be computed in the final weeks of the research project. With a greater understanding of the light pathway through the system shown in Fig 1.a, we can alter the hardware and use different lenses to make it more compact and suitable for intraoperative use. Understanding the path of the laser beam more precisely also allows us to maximize the amount of light reaching the brain and hence, improves the quality and precision of the blood flow map offered to the surgeon during his procedure.

Conclusion: By further understanding the path of light through the laser illumination piece with ray optics, we can be streamlining the laser illumination piece in future iterations. In addition, we can make the other pieces of the LSCI microscope attachments smaller, and lighter. Thus, because we can streamline the hardware, the maneuverability and applications of the hardware can become far greater. The enhancement of the hardware and quality of the LSCI blood flow images will help prove that LSCI is a promising imaging modality to guide surgeons and monitor cerebral blood flow during neurosurgery.

References: Richards L.M, J. Cereb. Blood Flow Metab. 2014. Vol. 1. Page 2.