2020-21 Annual Report
Guided Therapeutics (GTx) Research Program
Jonathan Irish (GTx Program Leader/Director, Clinical Faculty, TECHNA Research Institute)

GTx Program Staff: Jason Townson, PhD (Manager/Scientist), Michael Daly, PhD (Staff Scientist and Engineer), Harley Chan, PhD (Engineer), Robert Weersink, PhD (Physicist), Daniel Lin (Engineer), Jimmy Qiu (Engineer)

GTx International Scholar Scientist: Dr Nidal Muhanna MD PhD (Israel), Marco Ferrari MD (Italy), and Catriona Douglas MD (UK)

GTx Fellows: Drs. Axel Sahovaler, Donovan Eu, Catriona Douglas and Sharon Tzelnick

GTx Visiting Residents (Italy-Toronto Collaboration): Drs. Stefano Taboni, Tommaso Gualtieri and Leonardo Franz

The GTx Research Program, part of UHN's TECHNA Institute, continues to lead and support research, run translational clinical trials and develop new technologies and interventions in head and neck, skull base, thoracic and sarcoma cancer surgery. This research is completed by our multidisciplinary team of surgeons, radiation physicists, engineers, programmers, chemists, cancer biologists, and imaging specialists, using the key GTx infrastructure consisting of the GTx Operating Room (GTx-OR at the Toronto General Hospital) and the GTx-Lab (at Princess Margaret Cancer Research Tower). This year the GTx engineering, physics and scientific staff have been supporting the construction and development of operating room services at Sinai Health. During the past year, the GTx Program has continued to focus on translational research and the development of a broad range of new and continuing research projects:

Research:

•As part of the $5.5M 7-year Terry Fox New Frontiers Program Project Grant for "Porphysome Nanoparticle-Enabled Image-Guided Cancer Interventions", the GTx Program continues to collaboratively work on the development and translational research of nanoparticles for imaging and therapeutic use. This includes the GTx Program's continued research and development of porphysome nanoparticles (developed by and in collaboration with Dr. Gang Zheng) as an imaging and therapeutic (theranostic) agent for thyroid and oral cavity cancers. As part of this research effort, the GTx program (in collaboration with other research groups at UHN and Sunnybrook) has continued to advance porphysome-enabled photodynamic therapy (PDT) and photothermal therapy (PTT) as a potential treatment option for oral cavity and papillary thyroid cancer. Nanoparticle production scale up and preclinical studies completed as part of this collaboration is anticipated to lead to Health Canada IND approval and first in human clinical trials in 2022.

•Building upon the research completed as part of the Terry Fox New Frontiers Program Project, the GTx program is nearing completion of studies in pre-clinical small animal models to determine safety, efficacy and feasibility of using porphysome nanoparticles

for PDT or PTT treatment and fluorescence image guided surgery for H&N cancers. A new focus has emerged on establishing a collaboration with Ontario Veterinary College for translation research with a clinical veterinary dog population for optimization of safety, equipment and workflow, and efficacy in a size scale appropriate and spontaneously occurring non-human clinical population.

•Developed a 3D fluorescence imaging system for head and neck surgical guidance (OHNS Raymond Ng & Wendy Chui Innovation Fund); in 2021 demonstrated use of spatial frequency structured illumination to generate tumour depth maps in pre-clinical models (Daly et. al, SPIE BiOS, 2021).

•Continued multiple collaborative projects with University and Brescia and University of Padua (Italy) focused on 3-dimensionally printed stem cell scaffolding for bone reconstruction and other head and neck reconstruction projects (Irish/Gilbert/GTx).

•Improved reconstruction through new 3D modelling and multi-material printing capabilities. Additionally, in 2020-21, GTx 3D printing resources were used to produce supplies for UHN COVID requirements and related experiments (Davies et al, Laryngoscope, 2020).

•Evaluated custom augmented reality (AR) and virtual reality (VR) technologies for surgical training and guidance; in 2021, conducted pre-clinical studies quantifying the accuracy and usability of an in-house AR system for guiding sinonasal tumour resection (Sahovaler et. al., Frontiers in Oncology, Submitted 2021).

•Developed and translated image-guidance and 3D intraoperative imaging technologies for open and endoscopic sinonasal and maxilla resection; in 2021 completed pre-clinical study showing improved delineation of the posterior maxillary margin during endoscopic resection (Taboni et. al., Frontiers in Oncology, Submitted 2021).

•Reported on the use of cone-beam CT imaging for otology applications, including a feasibility study completed this year with colleagues from Sunnybrook (Drs. Dahm, Chen & Le) on eustachian tube dilation using a standard endovascular balloon (Dahm et. al., Otology & Neurotology, 2021).

•Conducted an international questionnaire-based study (Douglas et. al.) on OHNS health staff worries and perceptions of information during the COVID-19 pandemic. Responses were obtained from staff in Canada, the UK, Israel, Italy, Argentina and Singapore.

Education:

•Fellowships: 1) Donovan Eu successfully completed 2 years as GTx research (1 yr) and GTx clinical (1 yr) fellow and has returned to Singapore as a consultant at National University Hospital, 2) Tommaso Gualtieri, the 3rd GTx-Italy research fellow, successfully completed fellowship in February 2021 and has returned

•Supervised co-op students working on 3D fluorescence from undergraduate/graduate programs in biomedical engineering and medical physics, including: Jacqueline Fleisig (U of T); Ashley Gilbank, Murtuza Rajkotwala, Yasmeen El-Rayyes, and Arjun Jagota (McMaster).

Infrastructure Development:

•A replacement for the old cone-beam CT is being installed in the GTx lab. A new Siemens Cios Spin is currently being installed and will be ready for ongoing and new applications in fall 2021.

•A milestone has been reached in our ongoing collaboration with the Sinai Health team lead by Drs. Jay Wunder and Peter Ferguson. A new operating room (MS GTx2) has been built and is currently being equipped to translate GTx surgical navigation technology to Sinai Health ORs for osteosarcoma surgeries. It is anticipated the first clinical trials will occur in 2022.

•Preparation for translation (2022) of previously established machine learning techniques to recognize surgeon hand gestures for intraoperative visualization of 3D imaging in a sterile surgical environment.