

The Hospital For Sick Children

Cochlear Implant Research Lab **Karen Gordon, Blake Papsin**

The Cochlear Implant Laboratory at the Hospital for Sick Children continues to investigate auditory development and plasticity. We ask: 1) What aspects of auditory development are arrested by hearing loss; 2) What changes in the auditory system occur during the period of deafness; and 3) To what extent can auditory plasticity and development be promoted by cochlear implant use? We are also interested in cochlear implant design which seeks to improve the resilience of the device as well as to preserve residual hearing. Our work is supported by research funding from the Canadian Institutes of Health Research along with the Cochlear Americas Chair in Auditory Development and generous donations. Specific hypotheses which stem from these questions are tested through a number of studies currently underway.

Our team includes Stephanie Jewell, our Research Project Co-ordinator, and we have welcomed Carmen McNight as our new research engineer. Two graduate students at the University of Toronto, successfully defended their research theses in our laboratory during this past year. Salima Jiwani earned a PhD through the Institute of Medical Science and Nikolaus Wolter earned an MSc through the Clinician-Surgeon Training Program and the Institute of Medical Science.

Salima Jiwani studied the long term effects of unilateral cochlear implant use on the maturing auditory cortex. In collaboration with Dr. Sam Doesburg, we used new tools to assess the cortical networks involved in listening through a cochlear implant. We had already shown that single sided deafness through unilateral cochlear implant use allows abnormal strengthening of the hearing ear (including work by Daniel Wong during his PhD). Salima's work showed that this strengthening is further solidified once cortical maturation is reached with implications for pathways from the opposite ear.

Salima has presented this work internationally and was awarded with 14 student prizes and competitive funding. Of note, in the present reporting year, this work was awarded external funding from the Hearing Foundation of Canada and Ms. Jiwani earned a studentship award for her abstract to the Objective Measures in Auditory Implants conference. Ms. Jiwani has authored 4 papers while in our laboratory, has another in revision, and is preparing a paper for submission. She has moved to a full-time position with Cochlear Canada.

Nikolaus Wolter investigated vestibular function and balance in children using cochlear implants and found deficits in these areas through posturography, motion capture, and behavioral measures. Importantly, children's time to fall decreased while wearing their cochlear implants regardless of the type of sound presented in the environment (dynamic versus static directionless noise versus quiet). Dr. Wolter has been recognized for his work with 6 student awards, including a top prize for outstanding poster at the Collaborative program in Neuroscience Research Day at the University of Toronto and the Judy Chauvin Otolaryngology Resident Award, Department of Otolaryngology-Head & Neck Surgery, University of Toronto. He has authored 3 publications based on work done in our laboratory, has 1 in revision, and another 3 in preparation for submission. Dr. Wolter will begin his otolaryngology fellowship at Boston Children's Hospital in July 2016.

Current graduate students are Melissa Polonenko and Joshua Gnanasegaram who are both in the Institute of Medical Science at the University of Toronto. Melissa Polonenko is a clinical audiologist pursuing her PhD. She is studying the use of bimodal hearing (acoustic hearing in one ear and electrical hearing through a cochlear implant in the other). She has received 7 studentship awards (5 this year). She received the Ontario Student Graduate Award in 2 consecutive years and was ranked first place in her category for the Restrcomp Studentship Award

from the Hospital for Sick Children. Melissa has also received 2 awards for outstanding abstracts submitted by a student to international conferences this year.

Joshua Gnanasegaram joined the laboratory in September 2014 in the MSc program at the Institute of Medical Science. He is working in collaboration with Dr. Sharon Cushing, and with present otolaryngology fellow, Dr. William Parkes to investigate whether the vestibular system can be evoked by electrical stimulation from a cochlear implant in children. Results have been encouraging, revealing evoked responses in a proportion of children with and without residual vestibular function. Both Dr. Parkes and Mr. Gnanasegaram have been able to present this work at international conferences. A manuscript outlining the results at this stage is being prepared for publication.

We have enjoyed the opportunity to work with 3 returning summer students: Brigit Allemang, Patricia Ungureanu, and Catherine McCann. Catherine McCann's project explores the use of computational techniques to remove or suppress artifacts from electrophysiological recordings in cochlear implant users and has been funded by the Comprehensive Research Experience for Medical Students.

We continue to have important collaborations both locally, with Robert Harrison, Sharon Cushing, Adrian James, Sam Doesburg, Paolo Campisi, James Rutka, Sandra Trehub, Susan Blaser, and Frank Russo, nationally, with Isabelle Peretz, and internationally, with Robert Cowan and Richard van Hoesel.

The past year has been very productive: 9 publications were published or are in the press. Between this summer and last, we collectively presented over 20 abstracts at international meetings and gave more than two dozen invited talks internationally.

One of the highlights of the past year was our successful organization and co-chairing of the 8th International Symposium on Objective Measures in Auditory Implants, held October 14-17, 2014. The meeting was the largest to date held in North America and was very well received with 23 invited speakers, 81 open papers, and over 90 posters.

Paediatric Voice & Airway Research Lab Paolo Campisi, Vito Forte, Evan Propst

Exciting research is active along many fronts. We acknowledge and are thankful for the contributions of many of our past and present residents and fellows and are grateful for the financial support of our hospital innovation grants initiative as well as to our Foundation donor base support.

A partial project list is as follows:

- Voice therapy for the management of vocal fold nodules in children. This is a multi-centre (Toronto, Boston, Philadelphia, Milwaukee) randomized control trial comparing two types of voice therapy. The study was funded by an NIH grant. Targets for recruitment have been achieved. Congratulations to Ms. L. Russell, M. Nella and K. Simpson.
- HPV genotype and the clinical course of children with recurrent respiratory papillomatosis. This study was piloted in Toronto but will now be extended to other sites in the JoRRP interest group.
- Canadian JoRRP surveillance study. Data collection from the JoRRP interest groups is now complete. The national prevalence and incidence of JoRRP, 5 years after the introduction of HPV vaccination strategies, has been decreasing.
- Identifying genes responsible for the development of the normal and syndromic larynx and trachea.
- Development of a 22q11 mouse model to better understand laryngeal cleft and web formation.
- Creating lifelike models of the neck and airway as a simulator for tracheotomy and advanced airway surgical teaching.
- Creation of a variable tracheal construct for replacement of long segment tracheal stenosis.
- Studying the microvasculature and neovascularization of cartilaginous grafts using corrosion casting models and computer assisted analysis following laryngotracheal reconstruction.
- Dynamic modulation of endotracheal tube cuff pressure in humans in the intensive care unit.

- Use of ultrasonography to differentiate between thyroglossal duct cysts and midline dermoid cysts. Following retrospective analysis and development of a prediction algorithm, this has been instituted into clinical practice and prospective collection of data is ongoing.
- Demographics of choanal atresia in Canada: a population based study. Data has been collected from every pediatric centre in the country and publication is pending.
- Creation of a pediatric version of the Sniff'n Sticks olfactory battery of tests. This is a two-part multinational study. Part 1 (completed) tested children to select odours familiar and discernible to them. Part 2 (in progress) involves testing children with the new shortened version.
- Objective measures of the olfactory system in children.

OtoSim™ Lab

Paolo Campisi, Vito Forte

OtoSim™ has enjoyed another successful year thanks to the ongoing efforts of a great team and the support of many faculty members. Accumulated sales of the simulators have now surpassed the \$3.8 million mark.

Worldwide marketing and distribution strategies are being developed as the company continues to grow. The OtoSim™ has been adopted in more than 185 teaching institutions in over 20 countries.

Product development remains a key component of OtoSim Inc. Advanced OtoSim™ and OphthoSim™ self-learning software upgrades have been developed and marketed as well as 'mass teaching' and remote teaching capabilities for both the ear and eye simulation.

A partial list of projects is listed below:

- Objective evaluation of otoscopy skills amongst primary care trainees. This study examines the abilities of primary care learners in family medicine and paediatrics to evaluate tympanic membranes using the OtoSim™ simulator before

and after training with the unit. There is a long term follow up session assessing retention of otoscopy skills. The manuscript is being reviewed by the Journal of Surgical Education. [D. Oyewumi et al, Objective evaluation of otoscopy skills amongst family medicine, paediatric and otolaryngology residents]

- The use of an otoscopy simulator in an observed structured clinical examination (OSCE) was recently reviewed with Dr. David Wong, Undergraduate Education Lead for the Integrated OSCE, Faculty of Medicine, University of Toronto. J. Xu et al, Use of otoscopy simulation in medical student clinical evaluation. Submitted: Journal of Otolaryngology-Head & Neck Surgery.
- T.S. Fu et al, Evaluating the utility of otoscopy simulation in undergraduate medical education. Submitted: Journal of Otolaryngology-Head & Neck Surgery.
- D.J. Lee et al, Evaluation of an otoscopy simulator to teach otoscopy and normative anatomy to first year medical students. In press: Laryngoscope, 2015.
- J. Davies et al, Otoscopy simulation training in a classroom setting: a novel approach to teaching otoscopy to medical students. Laryngoscope, 124(11):2594-7, 2014.

Other Highlights:

- OphthoSim™ - A study exploring the utility of ophthalmoscopy simulation in the national ophthalmology bootcamp was undertaken in Toronto in June 2015. The data is currently being evaluated.
- Since 1982, The Ernest C. Manning Awards Foundation has been creating a culture of innovation in Canada by discovering, celebrating and rewarding Canadian innovators of all ages. In 2015, Dr. Vito Forte was nominated and selected as a finalist for the prestigious Ernest C. Manning Award.
- OtoSim™ was used by Drs. R. Nuss and J. Strychowsky (Boston Children's Hospital,

Harvard Medical School) at a recent humanitarian mission to Rwanda. This simulator was provided as part of the program by OtoSim Inc.



J. Strychowsky teaching with the OtoSim™ in the otolaryngology clinic at the University of Rwanda teaching hospital in Kigali.

Auditory Science Lab

Robert V. Harrison

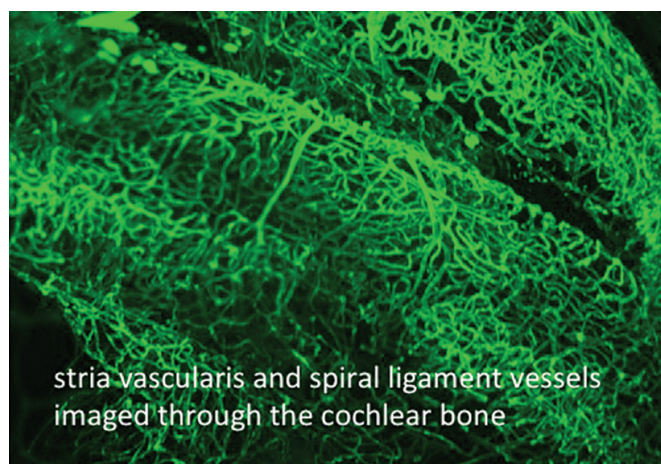
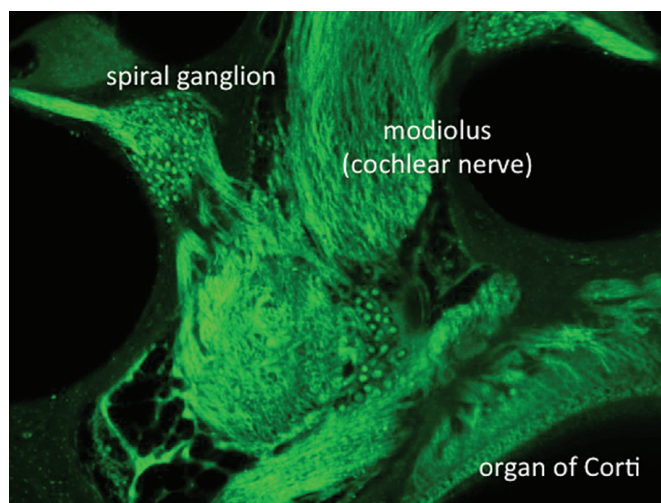
The Auditory Science Laboratory at SickKids has been part of our university department for over 30 years. We employ a wide range of research techniques to explore the structure and function of the normal and pathological inner ear and the development of the auditory brain. Our methods include brain imaging and electrophysiological techniques, including the recording of single neurons from different areas of the auditory brain. We also carry out evoked potential and oto-acoustic emission research in human subjects and in animal models. In our anatomical studies, we make histological evaluations of the inner ear with light and electron microscopy and we also probe neural activity patterns in the auditory brain with immuno-labeling techniques. In recent years we have mastered corrosion cast studies of vascular structures in the inner ear and also of the trachea and larynx.

A new research initiative this past year has been an investigation of the damage to cochlear capillary networks (e.g. stria vascularis) resulting from cytomegalovirus (CMV) infection. This work is part

of the PhD thesis work done by Mattia Carraro, and our project is in collaboration with Albert Park at the University of Utah. Mattia was recognized for his work by winning our PhD Raymond Ng Award.

Mattia has also introduced some novel imaging techniques, including light sheet microscopy, and has refined the method to allow whole cochlear specimens (mouse) to be viewed in detail without bone removal. In the examples shown below individual spiral ganglion cells, cochlear vasculature can easily be recognized.

A recent major achievement for one of our graduate students, Lisa D'Alessandro, was the completion and final defense of her PhD thesis on the developmental plasticity of the auditory midbrain; congratulations to Lisa. This past year has also been productive for our project manager Jaina Negandhi. She has been working on projects ranging from recording ABRs in animal models, studying midbrain activity patterns with c-fos labeling, and investigating audiometric data in children with auditory neuropathy.



This past year, through the funding with a CIHR team grant, we have had useful collaborations with other research teams including that of Lu-Yang Wang at SickKids and Vincent Lin at Sunnybrook Health Sciences Centre. In addition to basic laboratory research we have active collaboration with the SickKids cochlear implant team including Blake Papsin, Karen Gordon and Adrian James. The research funding climate in Canada has become rather unsettled to say the least. Federal funding from CIHR is very competitive. We are pleased to report that we have a new five-year research project funded by CIHR to study inhibitory and excitatory neural interactions during auditory brain development.

In this last year, our research has resulted in publication of eight peer-reviewed papers, as well as contributions to the latest edition (6th) of Cummings *Otolaryngology: Head and Neck Surgery*. Robert Harrison has also co-authored a book entitled: *“Understanding the Evidence: Wind Turbine Noise. The expert panel on wind turbine noise and human health”*.

As a result of hard work by our trainees and staff, the Auditory Science Laboratory has had a very productive year. Thank you all for your contributions.