Form Approved Through 6/30/15

American Otological Society Research Fund Grants & Awards

Application

Do not exceed character length restrictions indicated.

CHECK ONE *(guidelines for filling out application available on website)*

Research Fellowship ☐	Research Grant ☒
Clinical Investigations Research Grant ☒	Clinician Scientist Award ☐

1. TITLE OF PROJECT *(Do not exceed 81 characters, including spaces and punctuation.)*
Development of novel surgical instruments for endoscopic ear surgery

2. PROGRAM DIRECTOR/PRINCIPAL INVESTIGATOR

2a. NAME (Last, first, middle)
James, Adrian Lewis

2b. DEGREE(S)
DM FRCS (ORL-HNS)

2c. POSITION TITLE
Associate Professor

2d. MAILING ADDRESS *(Street, city, state, zip code)*
Hospital for Sick Children
555 University Avenue
Toronto
Ontario, M5G 1X8

2e. DEPARTMENT, SERVICE, LABORATORY, OR EQUIVALENT
Department of Otolaryngology - Head and Neck Surgery

2f. MAJOR SUBDIVISION
Faculty of Medicine, University of Toronto

2g. TELEPHONE AND FAX *(Area code, number and extension)*
TEL: 416 813 4938 FAX: 416 813 5036

E-MAIL ADDRESS:
adr.james@utoronto.ca

3. HUMAN SUBJECTS RESEARCH	3a. Research Exempt	If "Yes," Exemption No.
☒ No ☐ Yes	☒ No ☐ Yes	

3b. Federal-Wide Assurance No.	3c. Clinical Trial	3d. NIH-defined Phase III Clinical Trial
Canadian jursidiction	☒ No ☐ Yes	☒ No ☐ Yes

5. VERTEBRATE ANIMALS ☒ No ☐ Yes — 5a. Animal Welfare Assurance No. NA

6. ADMINISTRATIVE OFFICIAL TO BE NOTIFIED IF AWARD IS MADE
Name John Kearney
Title Manager, Grants Management Office
Address 686 Bay Street, Toronto ON M5G 0A4
Tel: 416-813-7654 FAX: 416-813-5085
E-Mail: john.kearney@sickkids.ca

7. OFFICIAL SIGNING FOR APPLICANT ORGANIZATION
Name Dr. Michael Salter
Title Chief of Research
Address 686 Bay Street, Toronto ON M5G 0A4
Tel: 416-813-6272 FAX: 416-813-5085
E-Mail: michael.salter@sickkids.ca

14. APPLICANT ORGANIZATION CERTIFICATION AND ACCEPTANCE: I certify th the statements herein are true, complete and accurate to the best of my knowledge, and accept the obligation to comply AOS Research Fund terms and conditions if a grant is awarded as a result of this application. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties.

SIGNATURE OF OFFICIAL NAMED IN 13. *(In ink. "Per" signature not acceptable.)*

DATE 2016-01-29

PROJECT SUMMARY (in 30 words or less)

To develop surgical instruments for endoscopic ear surgery to overcome the inherent limitations of one-handed surgery by incorporating multi-functionality into tools designed and developed using computer assisted design and modeling

RELEVANCE (See instructions):

The proposed research will benefit the treatment of otological disorders that are amenable to endoscopic ear surgery, most commonly, tympanic membrane perforation and cholesteatoma. Endoscopic ear surgery can improve outcomes such as completeness of cholesteatoma removal and post operative morbidity. Instruments designed around endoscopic requirements, accounting for temporal bone morphology and surgeon ergonomics will bring the advantages of the technique to more surgeons and patients.

PROJECT/PERFORMANCE SITE(S) (if additional space is needed, use Project/Performance Site Format Page)

Project/Performance Site Primary Location		
Organizational Name: University of Toronto		
Street 1: Hospital for Sick Children	Street 2: 555 University Avenue	
City: Toronto	County:	State:
Province: Ontario	Country: Canada	Zip/Postal Code: M5G 1X8

Additional Project/Performance Site Location		
Organizational Name:		
Street 1:	Street 2:	
City:	County:	State:
Province:	Country:	Zip/Postal Code:

SENIOR/KEY PERSONNEL. See instructions. *Use continuation pages as needed* to provide the required information in the format shown below. Start with Program Director(s)/Principal Investigator(s). List all other senior/key personnel in alphabetical order, last name first.

Name	Organization	Role on Project
James, Adrian Lewis	University of Toronto	Principal Investigator
Andrysek, Jan	University of Toronto	Faculty
Swarup, Arushri	University of Toronto	Graduate Student

OTHER SIGNIFICANT CONTRIBUTORS

Name	Organization	Role on Project
Dr James Drake	CIGITI	Head of facility
Thomas Looi	CIGITI	Facility coordinator
Dr John Rutka	Toronto General Hospital	Evaluating otologist
Dr Dave Pothier	Toronto General Hospital	Evaluating otologist
Dr Joe Chen	Sunnybrook Hospital	Evaluating otologist
Dr Vincent Lin	Sunnybrook Hospital	Evaluating otologist
Dr Blake Papsin	Hospital for Sick Children	Evaluating otologist
Dr Sharon Cushing	Hospital for Sick Children	Evaluating otologist

This section of the NIH application pertaining to Stem Cell Lines is not needed for the AOS applications.

The name of the program director/principal investigator must be provided at the top of each printed page and each continuation page.

RESEARCH GRANT

TABLE OF CONTENTS

* Follow the page limits for these sections indicated in the application instructions, unless the Funding Opportunity Announcement specifies otherwise.

Program Director/Principal Investigator (Last, First, Middle): James, Adrian Lewis

DETAILED BUDGET FOR INITIAL BUDGET PERIOD DIRECT COSTS ONLY	FROM July 2016	THROUGH June 2018

List PERSONNEL *(Applicant organization only)*
Use Cal, Acad, or Summer to Enter Months Devoted to Project
Enter Dollar Amounts Requested *(omit cents)* for Salary Requested and Fringe Benefits *(check AOS guidelines so see if allowed for your grant type!)*

NAME	ROLE ON PROJECT	Cal. Mnths	Acad. Mnths	Summer Mnths	INST.BASE SALARY	SALARY REQUESTED	FRINGE BENEFITS	TOTAL
James, Adrian Lewis	PD/PI	24			0	0	0	0
Swarup, Arushri	Graduate Student		16	8	32,300	32,300	0	32,300
Andrysek, Jan	Co-investigator		16	8	0	0	0	0
SUBTOTALS →						32,300	0	32300

CONSULTANT COSTS	0
EQUIPMENT *(Itemize)* High resolution commercial temporal bone models (Phacon): 3 at $300; Conventionl surgical instruments for modification (eg Rosen needles, T-tube introducers, cannulae, picks, Panetti dissectors, cautery handpieces and cable): $6000	6,900
SUPPLIES *(Itemize by category)* 3D printing materials for creating instrument prototypes and material for temporal bone models: $1500 per annum; Nitinol tubing: $1238.94pa; Materials for milling: $2500pa; Milling drill bits $350; Cadaveric temporal bones: 24 at $60	9,768
TRAVEL 0	0
INPATIENT CARE COSTS 0	0
OUTPATIENT CARE COSTS 0	0
ALTERATIONS AND RENOVATIONS *(Itemize by category)* 0	0
OTHER EXPENSES *(Itemize by category)* Computer aided design course (SolidWorks) $450 Publication costs $500	950

CONSORTIUM/CONTRACTUAL COSTS	DIRECT COSTS	
SUBTOTAL DIRECT COSTS FOR INITIAL BUDGET PERIOD *(Item 7a, Face Page)*		$ 49,918
CONSORTIUM/CONTRACTUAL COSTS	FACILITIES AND ADMINISTRATIVE COSTS	4,992
TOTAL DIRECT COSTS FOR INITIAL BUDGET PERIOD		$ 54,910

BUDGET FOR ENTIRE PROPOSED PROJECT PERIOD
DIRECT COSTS ONLY

BUDGET CATEGORY TOTALS	INITIAL BUDGET PERIOD *(from Form Page 4)*	2nd ADDITIONAL YEAR OF SUPPORT REQUESTED	3rd ADDITIONAL YEAR OF SUPPORT REQUESTED	4th ADDITIONAL YEAR OF SUPPORT REQUESTED	5th ADDITIONAL YEAR OF SUPPORT REQUESTED
PERSONNEL: *Salary and fringe benefits. Applicant organization only.*	32,300				
CONSULTANT COSTS	0				
EQUIPMENT	6,900				
SUPPLIES	9,768				
TRAVEL	0				
INPATIENT CARE COSTS	0				
OUTPATIENT CARE COSTS	0				
ALTERATIONS AND RENOVATIONS	0				
OTHER EXPENSES	950				
DIRECT CONSORTIUM/ CONTRACTUAL COSTS	0				
SUBTOTAL DIRECT COSTS *(Sum = Item 8a, Face Page)*	49,918				
F&A CONSORTIUM/ CONTRACTUAL COSTS	4,992				
TOTAL DIRECT COSTS	54,910				

TOTAL DIRECT COSTS FOR ENTIRE PROPOSED PROJECT PERIOD **$** 54,910

JUSTIFICATION. Follow the budget justification instructions exactly. Use continuation pages as needed.

Salary for Personnel: The salary requested is for a Master's Student, $16,150 USD per year for two years. This is the stipend cost at IBBME (Institute for Biomaterials and Biomedical Engineering) at the University of Toronto for a MASc student.

Equipment: Three different re-usable high definition printed temporal bone models will be used for prototype testing. Conventional ear surgery instruments will be obtained and modified for innovative single handed multi-purpose prototypes.

Supplies: Year 1: The budget for supplies consists of materials required for preparation of instrument prototypes (3D printing and metal milling), and preparation of dry lab models for evaluation of instruments (3D printed temporal bones, synthetic graft materials, silastic putty) and cadaveric temporal bones.

Other Expenses:

Funding to attend a course in Solidworks is requested, at a cost of $450, to gain additional proficiency in computer-aided design which will be used by the student to create prototypes of the surgical instruments.

Publication costs for photocopying, inter-library loan, thesis binding, colour illustrations are estimated at $500.

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors in the order listed on Form Page 2.
Follow this format for each person. **DO NOT EXCEED FOUR PAGES.**

NAME	POSITION TITLE
James, Adrian Lewis	Associate Professor Dept of ORL-HNS University of Toronto
eRA COMMONS USER NAME (credential, e.g., agency login)	

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	MM/YY	FIELD OF STUDY
University of Cambridge, Cambridge, UK	MA	06/87	Medical Sciences
University of Oxford, Oxford, UK	BM BCh	06/90	Clinical Medicine
Oxford Deanery, UK	$FRCS_{(ORL-HNS)}$	06/00	ORL-HNS Residency
University of Toronto, Toronto, Canada	-	06/02	Peds ORL fellowship
University of Oxford, Oxford, UK	DM	06/06	Auditory Science

A. Personal Statement

Dr. Adrian James is an Associate Professor in pediatric Otolaryngology - Head and Neck Surgery at the University of Toronto Canada. He works at The Hospital for Sick Children with a predominantly otologic practice, focusing particularly in chronic middle ear disease and including cochlear implantation. He has established an international reputation for the application of endoscopes to pediatric cholesteatoma surgery and is also well known for monitoring the outcome of his surgical intervention with a database that now includes over 1000 middle ear operations.

He has published over 100 otolaryngologic manuscripts with more than 80 in peer reviewed journals. He has received over $80,000 in grant funding as a principle investigator and is co-investigator on a $1,250,000 CIHR grant for investigation of binaural hearing pathways. He reviews for many otolaryngology journals and is an Editor for ENT Disorders Group in the Cochrane Collaboration. Of most relevance to this proposal, his previous publications include several reports detailing his experience of endoscopic ear surgery, investigations using cadaveric temporal bone models, and reports detailing the minimally invasive cochlear implant surgery from the development of novel instrumentation to assessment of subsequent patient outcome.

In 2013 he received the Teacher of the Year Award from the Department of ORL-HNS at the University of Toronto. He has been an instructor on Temporal Bone and Endoscopic Ear Surgery Courses around the world and organizes the International P8ediatric Temporal Bone Surgery Course in Toronto. Other academic accomplishments include: award of Doctorate of Medicine (University of Oxford) in 2007 for work on contralateral suppression of otoacoustic emissions; Mosher Award (for outstanding clinical research) for his Triological Society thesis in 2010 on translational application of contralateral suppression of OAE test to infants at risk of auditory neuropathy; promotion to Associate Professor at the Department of Otolaryngology – Head and Neck Surgery, University of Toronto in 2011; inducted to American Otological Society in 2011 and Collegium Oto-Rhino-Laryngologicum Amicitiae Sacrum (CORLAS) 2015; American Academy of Otolaryngology-Head and Neck Surgery Foundation Honor Award in 2012.

B. Positions and Honors

Staff Pediatric Otolaryngologist, The Hospital for Sick Children, Canada

Associate Professor, University of Toronto, Canada

Project Investigator, Research Institute, The Hospital for Sick Children, Canada

Associate Member, Institute of Medical Science, University of Toronto

2012 Honor Award, American Academy of Otolaryngology - Head and Neck Surgery. (Distinction)

2010 Mosher Award, Triological Society, United States. Awarded for outstanding clinical research.

2012-3 Teacher of the Year Award, Dept of Otolaryngology - Head & Neck Surgery, University of Toronto

C. Selected Peer-reviewed Publications

Reports utilizing temporal bone models

1. Erovic BM, Daly MJ, Chan HH, James AL, et al. Evaluation of intraoperative cone beam computed tomography and optical drill tracking in temporal bone surgery. Laryngoscope. 2013 Nov;123(11):2823-8.

2. Monteiro E, Das P, Daly M, Chan H, Irish J and James A. Usefulness of cone-beam computed tomography in determining the position of ossicular prostheses: a cadaveric model. Otol Neurotol. 2011 Oct;32(8):1358-63.

3. Barker E, Trimble K, Chan H, Ramsden J, Nithiananthan S, James A, et al. Intraoperative use of cone-beam computed tomography in a cadaveric ossified cochlea model. Otolaryngol Head Neck Surg. 2009;140(5):697-702.

Reports of endoscopic ear surgery

4. James AL, Cushing SC, Papsin BP. Residual cholesteatoma after endoscope-guided surgery in children. Otology & Neurotology. EPub 2015 Dec18.

5. James AL. Endoscopic middle ear surgery in children. Otolaryngol Clin North Am. 2013 Apr;46(2):233-44.

6. Badr-El-Dine M, James AL, Panetti G, Marchioni D, Presutti L and Nogueira JF. Instrumentation and technologies in endoscopic ear surgery. Otolaryngol Clin North Am. 2013 Apr;46(2):211-25.

7. James AL. Approaches to cholesteatoma with an intact ossicular chain: Combined use of microscope, endoscope and laser. Cholesteatoma and Ear Surgery – An Update. 2013:pp. 333-336.

8. James AL, Papsin BC, Trimble K, Ramsden J, Sanjeevan N, Bailie N and Chadha NK. Tympanic membrane retraction: An endoscopic evaluation of staging systems. Laryngoscope. 2012 May;122(5):1115-20.

9. James AL and Papsin BC. Ten top considerations in pediatric tympanoplasty. Otolaryngol Head Neck Surg. 2012 Dec;147(6):992-8.

Other reports of middle ear surgery

10. Peer S, Papsin BC and James AL. Cholesteatoma and tympanic membrane retraction in children. In: Paparella's Textbook of Otolaryngology. 2016 In press.

11. Wolter NE, Holler T, Cushing SL, Chadha NK, Gordon KA, James AL, Papsin BC. Pediatric ossiculoplasty with titanium total ossicular replacement prosthesis. Laryngoscope. 2015 Mar;125(3):740-5.

12. James AL and Papsin BC. Some considerations in congenital cholesteatoma. Curr Opin Otolaryngol Head Neck Surg. 2013 Oct;21(5):431-9.

13. Harris L, Cushing SL, Hubbard B, Fisher D, Papsin BC and James AL. Impact of cleft palate type on the incidence of acquired cholesteatoma. Int J Pediatr Otorhinolaryngol. 2013 May;77(5):695-8.

14. Kandasamy T, Papsin BC, Cushing SL and James AL. Effectiveness of cartilage tympanoplasty after erosion of the incus in children with cholesteatoma. Cholesteatoma and Ear Surgery – An Update. 2013:pp. 459-462.

15. James AL. Implantable hearing aids: Candidacy considerations in pediatric cholesteatoma. Cholesteatoma and Ear Surgery – An Update. 2013:pp. 293-296.

16. James AL. The effect of tympanostomy tubes on tympanic membrane retraction in children with cleft palate. Cholesteatoma and Ear Surgery – An Update. 2013:pp. 309-312.

17. Osborn AJ, Papsin BC and James AL. Clinical indications for canal wall-down mastoidectomy in a pediatric population. Otolaryngol Head Neck Surg. 2012 Aug;147(2):316-22.

18. Gotha L, Cushing S and James AL. Cholesteatoma with congenital eustachian tube obstruction. Otolaryngol Head Neck Surg. 2011 Oct;145(4):703-4.

19. James AL., Papsin, B.C., Blaser, S. Determining the growth rate of congenital cholesteatoma. In: Surgery of the ear - current topics. Ozgirgin, O.N., (Ed.). Rekmay Publishing Ltd, Antalya, Turkey. pp. 40-43. 2009.

20. James AL, Chadha, N., Chauhan, N., et al. Mutations of the GJB2 gene in children with cholesteatoma. In: Surgery of the ear - current topics. Ozgirgin, O.N., (Ed.). Rekmay Publishing Ltd, Antalya, Turkey. pp. 25-28. 2009.

21. Propst EJ, Blaser S, Trimble K, James A, Friedberg J and Papsin BC. Cochleovestibular anomalies in children with cholesteatoma. Laryngoscope. 2008 Mar;118(3):517-21.

22. James AL, Chen J. Diagrammatic recording of tympanomastoid procedures. Clin Otolaryngol. 2007; 32(4): 301-2.

23. Lin V, Daniel S, James A and Friedberg J. Bilateral cholesteatomas: the hospital for sick children experience. J Otolaryngol. 2004 Jun;33(3):145-50.

Reports on surgical instrument development and outcome for minimally invasive cochlear implant surgery

24. Eskander A, Gordon KA, Kadhim L, et al. Low pediatric cochlear implant failure rate: contributing factors in large-volume practice. Arch Otolaryngol Head Neck Surg. 2011 Dec;137(12):1190-6.

25. Das Purkayastha PK, Jewell S, James AL, Gordon K and Papsin B. Soft tissue complications after pediatric cochlear implantation in children younger than 12 months. Otol Neurotol. 2011 Jul;32(5):780-3.

26. Ramsden JD, Papsin BC, Leung R, James A and Gordon KA. Bilateral simultaneous cochlear implantation in children: our first 50 cases. Laryngoscope. 2009 Dec;119(12):2444-8.

27. Chadha NK, James AL, Gordon KA, Blaser S and Papsin BC. Bilateral cochlear implantation in children with anomalous cochleovestibular anatomy. Arch Otolaryngol Head Neck Surg. 2009 Sep;135(9):903-9.

28. Davids T, Ramsden JD, Gordon KA, James AL and Papsin BC. Soft tissue complications after small incision pediatric cochlear implantation. Laryngoscope. 2009 May;119(5):980-3.

29. Cushing SL, MacDonald L, et al. Successful cochlear implantation in a child with Keratosis, Icthiosis and Deafness (KID) Syndrome and Dandy-Walker malformation. Int J Pediatr Otorhinolaryngol. 2008 ;72(5):693-8.

30. Campisi P, James A, Hayward L, Blaser S and Papsin B. Cochlear implant positioning in children: a survey of patient satisfaction. Int J Pediatr Otorhinolaryngol. 2004 Oct;68(10):1289-93.

31. James AL, Papsin B.C. Cochlear implant surgery at 12 months of age or younger. Laryngoscope (2004) 114, 2191-2195.

32. James AL, Papsin B.C. Device fixation and small incision access for pediatric cochlear implants. Int J Pediatr Otorhinolaryngol (2004) 68, 1017-1022.

Other reports of otologic surgery and auditory science

33. James AL, Cushing SC and Papsin BC. Diagnostic Approach to Common Pediatric Otologic Problems. In: Sataloff's Comprehensive Textbook of Otolaryngology. Hartnick C. 2016. Vol. 6 pp107-118. JP Medical Publishers

34. Harrison RV, Gordon KA, Papsin BC, Negandhi J, James AL. Auditory neuropathy spectrum disorder (ANSD) and cochlear implantation. International Journal of Pediatric Otolaryngology. 2015 Dec. 79(12)1980-7.

35. Konomi U, Kanotra S, James AL and Harrison RV. Age related changes to the dynamics of contralateral DPOAE suppression in human subjects. J Otolaryngol Head Neck Surg. 2014;43(1):15.

36. Wolter NE, Harrison RV and James AL. Separating the contributions of olivocochlear and middle ear muscle reflexes in modulation of distortion product otoacoustic emission levels. Audiol Neurootol. 2014;19(1):41-8.

37. Osborn HA, Cushing SL, Gordon KA, James AL and Papsin BC. The management of acute mastoiditis in children with cochlear implants: Saving the device. Cochlear Implants Int. 2013 Nov;14(5):252-6.

38. Harrison RV, Konomi U, Kanotra S and James AL. Postnatal maturation of contralateral DPOAE suppression in a precocious animal model (chinchilla) of the human neonate. Acta Otolaryngol. 2013 Apr;133(4):383-9.

39. Cushing SL, Gordon KA, Rutka JA, James AL and Papsin BC. Vestibular end-organ dysfunction in children with sensorineural hearing loss and cochlear implants. Otol Neurotol. 2013 Apr;34(3):422-8.

40. Chung J, Cushing SL, James AL, Gordon KA and Papsin BC. Congenital cholesteatoma and cochlear implantation: Implications for management. Cochlear Implants Int. 2013 Jan;14(1):32-5.

41. James AL. The practical implications of TARGET for adenoidectomy in children with otitis media with effusion. Clin Otolaryngol. 2012 Jun;37(3):174-5.

42. Wolter NE, Harrison RV, James AL. Contralateral suppression of otoacoustic emissions. In: Naz S., ed. Hearing Loss (2012). ISBN: 978-953-51-0366-0. http://www.intechopen.com/

43. Propst EJ, George T, Janjua A, James A, Campisi P and Forte V. Removal of impacted cerumen in children using an aural irrigation system. Int J Pediatr Otorhinolaryngol. 2012 Dec;76(12):1840-3.

44. Wolter NE, Dell SD, James AL and Campisi P. Middle ear ventilation in children with primary ciliary dyskinesia. Int J Pediatr Otorhinolaryngol. 2012 Nov;76(11):1565-8.

45. Valero J, Blaser S, Papsin BC, James AL and Gordon KA. Electrophysiologic and behavioral outcomes of cochlear implantation in children with auditory nerve hypoplasia. Ear Hear. 2012 Jan-Feb;33(1):3-18.

46. James AL. The assessment of olivocochlear function in neonates with real-time distortion product otoacoustic emissions. Laryngoscope. 2011 Jan;121(1):202-13.

47. James A, Burton M. Betahistine for Ménière's disease or syndrome. Cochrane Database Syst Rev. 2011 Jan. Updated review; Issue 3, January 2011.

48. Chadha NK, Chadha R, James AL. Why are children deaf? Paed Child Health. Paediatrics and Child Health (2009) 19(10): 441-446

49. Ramsden JD, Papaioannou V, Gordon KA, James AL and Papsin BC. Parental and program's decision making in paediatric simultaneous bilateral cochlear implantation. Int J Pediatr Otorhinolaryngol. 2009 Oct;73(10):1325-8.

50. Gordin A, Papsin B, James A and Gordon K. Evolution of cochlear implant arrays result in changes in behavioral and physiological responses in children. Otol Neurotol. 2009 Oct;30(7):908-15.

51. James AL, Chadha NK, Papsin BC, Stockley TL. Pediatric cholesteatoma and variants in the gene encoding connexin 26. Laryngoscope. 2010 Jan;120(1):183-7.

52. Cushing SL, Papsin BC, Rutka JA, et al. Vestibular end-organ and balance deficits after meningitis and cochlear implantation in children correlate poorly with functional outcome. Otol Neurotol. 2009 Jun;30(4):488-95.

53. Crawford MW, White MC, Propst EJ, et al. Dose-dependent suppression of the electrically elicited stapedius reflex by general anesthetics in children undergoing cochlear implant surgery. Anesth Analg. 2009;108(5):1480-7.

54. Chadha NK, Gordon KA, James AL and Papsin BC. Tinnitus is prevalent in children with cochlear implants. Int J Pediatr Otorhinolaryngol. 2009 May;73(5):671-5.

55. Cushing SL, Papsin BC, Rutka JA, James AL et al. Evidence of vestibular and balance dysfunction in children with profound sensorineural hearing loss using cochlear implants. Laryngoscope. 2008;118(10):1814-23.

56. Harrison RV, Sharma A, Brown T, Jiwani S and James AL. Amplitude modulation of DPOAEs by acoustic stimulation of the contralateral ear. Acta Otolaryngol. 2008 Apr;128(4):404-7.

57. Cushing SL, Chia R, James AL, Papsin BC and Gordon KA. A test of static and dynamic balance function in children with cochlear implants: the vestibular olympics. Arch Otolaryngol Head Neck Surg. 2008 Jan;134(1):34-8.

58. Trimble K, Blaser S, James AL and Papsin BC. Computed tomography and/or magnetic resonance imaging before pediatric cochlear implantation? Developing an investigative strategy. Otol Neurotol. 2007 ;28(3):317-24.

59. Blaser S, Propst EJ, Martin D, Feigenbaum A, James AL, Shannon P and Papsin BC. Inner ear dysplasia is common in children with Down syndrome (trisomy 21). Laryngoscope. 2006 Dec;116(12):2113-9.

60. Chan Y, Campisi P, James AL and Papsin BC. Tympanic membrane changes following paediatric cochlear implantation. Cochlear Implants Int. 2005 Mar;6(1):10-5. doi: 10.1002/cii.16.

61. James AL, Harrison RV, Pienkowski M, Dajani HR and Mount RJ. Dynamics of real time DPOAE contralateral suppression in chinchillas and humans. Int J Audiol. 2005 Feb;44(2):118-29.

62. Thorp M.A., James AL. Prosper Meniere. Lancet (2005) 366, 2137-2139.

63. James A, Thorp M. Meniere's disease. Clin Evid (2005) 14, 659-656.

64. James A L. Real Time Measurement of Distortion Product Otoacoustic Emissions in the Assessment of the Olivocochlear Contralateral Reflex. Doctor of Medicine Thesis. University of Oxford, 2005.

65. Kaplan DM, James AL, Thorp MA, Mount RJ and Harrison RV. Effects of middle ear application of Cipro HC Otic Suspension in an animal model. J Otolaryngol. 2004 Jun;33(3):160-4.

66. James AL, Daniel SJ, Richmond L and Papsin BC. Skin breakdown over cochlear implants: prevention of a magnet site complication. J Otolaryngol. 2004 Jun;33(3):151-4.

67. Rotenberg BW, James AL, Fisher D, Anderson J and Papsin BC. Establishment of a bone-anchored auricular prosthesis (BAAP) program. Int J Pediatr Otorhinolaryngol. 2002 Dec 2. 2002 Dec 2;66(3):273-9.

D. Research Support

2014 Principal Investigator. Mastoid Pneumatization: A novel method of volumetric assessment. Harry Barberian Research Fund. Collaborators: Peer S, Wolter N. $5,000 CAD.

2011 Principal Investigator. A novel hearing test for neonates. Perioperative Services, Hospital for Sick Children. Innovation Grant. Collaborator: Harrison, RV. $48,400 CAD.

2010-15 Co-Principal Investigator. Development and Ageing of Binaural Hearing. Canadian Institutes of Health Research - CIHR. Team Grant: Harrison RV, James AL, Lin V, Friesen L. $1,250,000 CAD.

2008 Principal Investigator. Assessment of hearing loss from jaundice in premature babies. Connaught Fund. University of Toronto. $16,838 CAD.

2002 Principal Investigator. Investigation of hearing screening with real time otoacoustic emissions. The Hearing Foundation of Canada . $22,000 CAD.

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors in the order listed on Form Page 2.
Follow this format for each person. **DO NOT EXCEED FOUR PAGES.**

NAME	POSITION TITLE
Andrysek, Jan	Assistant Professor Institute of Biomaterial & Biomedical Engineering, University of Toronto
eRA COMMONS USER NAME (credential, e.g., agency login)	

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	MM/YY	FIELD OF STUDY
University of Guelph, Ontario, Canada	BSc(Hons)	02/98	Biological Engineering
University of Toronto, Ontario, Canada	MASc	11/00	Biomedical Engineering
Utrecht University, Utrecht, Netherlands	PhD	06/09	Health Sciences

A. Personal Statement

Briefly describe why Dr. Andrysek leads a research team at the Bloorview Research Institute of Holland Bloorview Kids Rehabilitation hospital, Canada's largest teaching hospital focused on paediatric disabilities. He also holds a faculty appointment within the Institute of Biomaterials and Biomedical Engineering, University of Toronto and directs the Clinical Engineering graduate program there. His research program focuses on the development and improvement of treatments and assistive technologies for children and youth with limb deficiencies. His publication record includes 30+ peer-reviewed journal papers. Dr. Andrysek has supervised over 40 students, 21 at the graduate level. In terms of knowledge and technology translation, his team has patented and commercialized a number of prosthetic technologies stemming from his research. Most recently, Dr. Andrysek is the co-founder and Chief Scientific Officer of Legworks Inc. (www.legworks.org), a social for-profit enterprise focused on improving prosthetic technologies and care for individuals with amputations worldwide. Dr. Andrysek has worked for the past four years with organizations such the International Committee of the Red Cross, the largest NGO prosthetic care provider operating in over 40 countries, to develop and implement better prosthetic care and technologies for children and adults around the world. He has received awards for his work including the Clifford Chadderton Award for Prosthetics and Orthotics Research, and recently a prosthetic knee technology developed in his lab claimed first price at the 2015 Accessibility Innovation Showcase Tech Pitch Competition sponsored by the Government of Ontario. The knee technology is also included in the Compendium of Innovative Health Technologies, World Health Organization (WHO). His work has been highlighted in the media including the Discovery channel - Daily Planet, Readers Digest, CBC Radio – Ideas, Toronto Star, CBC news and others. Over his academic career Dr. Andrysek has secured as principal applicant over $1.5 million in funding from numerous grants including the CFI/MRI John R. Evans Leaders Fund, NSERC Engage, NSERC Discovery, CIHR PoP, OCE Market Readiness, and Grand Challenges Canada Phase I and Phase II funding.

B. Positions and Honors

2005 Researcher/Scientist, Bloorview Research Institute, Holland Bloorview Kids Rehabilitation Hospital, Toronto, Ontario

2010 Assistant Professor, Biomaterials and Biomedical Engineering, Inst. of, University of Toronto, Toronto, Ontario

2015 Associate Director, Clinical Engineering Program, Biomaterials and Biomedical Engineering, Inst. of, University of Toronto, Toronto, Ontario

2015 Chief Scientific Officer, Legworks.org, Toronto, Ontario, Canada

2013 Adjunct Scientist, Toronto Rehab Institute (TRI), Toronto, Ontario

2013 Cross appointed faculty, Mechanical and Industrial Eng. University of Toronto, Toronto, Ontario

2013 Affiliate, Center for Global Engineering, Toronto, Ontario

2011 Associate, Rehabilitation Science (Graduate), University of Toronto, Toronto, Ontario

C. Selected Peer-reviewed Publications

1. Funk, L, Thies D, Wright V, Andrysek J, Rispin K. The Lower Limb Function Questionnaire: reliability and validity of a patient report measure for prosthetic and orthotic users. Disability and Rehabilitation. Accepted Dec. 2015. Co-Principal Author.

2. Rogers Emma, Leinweber M, Andrysek J. Analysis of terrain effects on the interfacial force distribution at the hand and forearm during crutch gait. Disability and Rehabilitation 0 Assistive Technology. Accepted 2015. Senior Responsible Author.

3. Chen C, Clements RJ, Biddiss E, Fairley K, Torres-Moreno R, Andrysek J. Evaluation of an instrument-assisted dynamic prosthetic alignment technique for individuals with transtibial amputation. Prosthetics Orthotics International. 2015 Jan. In Press. Senior Responsible Author.

4. Feick E, Carswell PR, Luis M, Corbin M, Campbell S, Salbach NM, Torres-Moreno R, Andrysek J. Examining the nature of balance and mobility deficits at the body function and activity level in children with unilateral lower-limb amputation. Prosth Orth Int. 2014 Dec. In Press (Trainee publication, Feick E, Carswell PR, Luis M, Corbin M,). Senior Responsible Author.

5. Andrysek J, Klejman S, Kooy J. Forces and moments in knee-ankle-foot orthoses while walking on irregular surfaces: a case series study. Prosth Orth Int. 2014 Apr;38(2):104-13. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23722598. Principal Author.

6. Kam S, Kent M, Khodaverdian A, Daiter L, Njelesani J, Cameron D, Andrysek J. The influence of environmental and personal factors on participation of lower-limb prosthetic users in low-income countries: Prosthetists' perspectives. Disability and Rehabilitation: Assistive Technology. 2014 Mar. In Press (Trainee publication, Kam S, Kent M, Khodaverdian A, Daiter L,). Senior Responsible Author.

7. Sharma A, Leineweber M, Andrysek J. The effect of cognitive and prosthetic liner on volitional response times to vibrotactile feedback. JRRD. 2014. In Press (Trainee publication, Sharma, Aman). Senior Responsible Author.

8. Sharma A, Torres-Moreno R, Zabjek K, Andrysek J. Toward an artificial sensory feedback system for prosthetic mobility rehabilitation: An examination of sensorimotor responses. JRRD. 2014;51(6):907-17 (Trainee publication, Sharma, Aman). Senior Responsible Author.

9. Wyss D, Lindsay S, Cleghorn WL, Andrysek J. Priorities in lower limb prosthetic service delivery based on an international survey of prosthetists in low- and high-income countries. Prosth Orth Int. 2013 Dec;[Epub ahead of print]. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24335154 (Trainee publication, Wyss, Dominik). Senior Responsible Author.

10. Wyss D, Cleghorn WL, Andrysek J. Application of Quality Function Deployment for the development of a prosthetic knee joint. AES Technical Reviews Part C: International Journal of Advances and Trends in Engineering Materials and their Applications (IJATEMA). 2013;1(1):67-75 (Trainee publication, D Wyss). Senior Responsible Author.

11. Andrysek J, Klejman S, Kooy J. Examination of knee joint moments on the function of stance-control orthoses during walking. Journal of Applied Biomechanics. 2012 Nov 21;29(4):474-80. Principal Author.

12. Irwin J, Fehlings D, Wright V, Zabjek K, Klejman S, Andrysek J, Biddis E. Active video game play in children with cerebral palsy: Potential for physical activity promotion and rehabilitation therapies. Arch Phys Med Rehabil. 2012 Aug;93(8):1488-56. Coauthor or Collaborator.

13. Christensen J, Andrysek J. Examining the associations amongst clinician demographics, the factors involved in the implementation of evidence-based practice and the access of clinicians to sources of information. Prosth Orth Int. 2012;36(1):87-94 (Trainee publication, Christensen J). Senior Responsible Author.

14. Andrysek J, Klejman S, Steinnagel B, Torres-Moreno R, Zabjek K, Salbach N, Moody, K. Preliminary evaluation of commercially available videogame system (WiiFit) as an adjunct therapeutic intervention for improving balance among children and adolescents with lower limb amputations. Arch Phys Med Rehabil. 2012;93(2):358-366. Principal Author.

15. Howcroft J, Klejman S, Fehlings D, Wright V, Zabjek K, Andrysek J, Biddiss E. Active video game play in children with cerebral palsy: potential for physical activity promotion and rehabilitation therapies. Arch Phys Med Rehabil. 2012;93(8):1448-56. Coauthor or Collaborator.

16. Michalski A, Glazebrook CM, Martin AJ, Wong WWN, Kim AJW, Moody KD, Salbach NM, Steinnagel B, Andrysek J, Torres-Moreno R, Zabjek K. Assessment of the postural control strategies used to play two Wii FitTM videogames. Gait Posture. 2012;36(3):449-53. Coauthor or Collaborator.

17. Furse A, Cleghorn W, Andrysek J. Improving the gait performance of non-fluid-based swing-phase control mechanisms in above-knee prostheses. IEEE Trans Biomed Eng. 2011 May 16. (epub). (Trainee publication, Furse A). Senior Responsible Author.

18. Andrysek J, Klejman S, Heim W, Torres Moreno R, Steinnagel B, Glasford, S. Mobility function of a prosthetic knee joint with an automatic stance-phase lock. Prosth Orth Int. 2011;35(2):163-170. Principal Author.

19. Furse A, Cleghorn W, Andrysek J. Development of a low-technology prosthetic swing-phase mechanism. J Med Biomed Eng. 2011;31(2):145-150 (Trainee publication, Furse A). Principal Author.

20. Andrysek J, Christensen J, Dupuis A. Factors influencing evidence-based practice in prosthetics and orthotics. Prosth Orth Int. 2011;35(1):30-38 (Trainee publication, J. Christensen). Senior Responsible Author.

21. Andrysek J, Christensen J, Dupuis A. Factores que influyen en la práctica basada en la evidencia en los campos protésico y ortésico (Factors influencing evidence-based practice in prosthetics and orthotics). Ortoprostetica-Ayudas. 2011;72:52-60. Senior Responsible Author.

22. Andrysek J. Lower-limb prosthetic technologies in the developing world: a review of literature from 1994 to 2010. Prosth Orth Int. 2010;34(4):378-398. Principal Author.

23. Reist T, Andrysek J, Cleghorn W. Topology Optimization of an Injection Moldable Prosthetic Knee Joint. Computer-Aided Design and Applications. 2010;7(2):247-256 (Trainee publication, R. Reist). Senior Responsible Author.

24. Klejman S, Andrysek J, Dupuis A, Wright V. Test-retest reliability of discrete gait parameters in children with cerebral palsy. Arch Phys Med Rehabil. 2010;91(5):781-7. Co-Principal Author.

25. Harrison D, Andrysek J, Cleghorn W. Feasibility and design of a low-cost prosthetic knee joint using a compliant member for stance-phase control. J. Med Dev. 2010;4(2) (Trainee publication, Harrison D). Senior Responsible Author.

26. Andrysek J, Liang T, Steinnagel B. Evaluation of a prosthetic swing-phase controller with electrical power generation. IEEE Trans Neural Syst Rehabil Eng. 2009;17(4):390-6. Principal Author.

27. Redekop S, Andrysek J, Wright V. Single-session reliability of discrete gait parameters in ambulatory children with cerebral palsy based on GMFCS level. Gait Posture. 2008;28(4):627-33. Co-Principal Author.

28. Andrysek J, Redekop S, Matsui N, Kooy J, Hubbard S. A method to measure the accuracy of loads in knee-ankle-foot orthoses using conventional gait analysis applied to persons with poliomyelitis. Arch Phys Med Rehabil. 2008;89(7):1372-79. Principal Author.

29. Andrysek J, Chau G. A self-energizing electromechanical swing-phase controlled knee joint prostheses: Feasibility study. IEEE Trans Biomed Eng. 2007;54(12):2276-83. Principal Author.

30. Andrysek J, Redekop S, Naumann S. Preliminary evaluation of an automatically stance-phase controlled pediatric prosthetic knee joint using quantitative gait analysis. Arch Phys Med Rehabil. 2007;88:464-470. Co-Principal Author.

31. Andrysek J, Naumann S, Cleghorn W. Design and quantitative evaluation of a stance-phase controlled prosthetic knee joint for children. IEEE Trans Neural Syst Rehabil Eng. 2005;13(4):369-378. Co-Principal Author.

32. Andrysek J, Naumann S, Cleghorn W. Design characteristics of paediatric prosthetic knees. IEEE Trans Neural Syst Rehabil Eng. 2004;12(4):368-378. Co-Principal Author.

33. Otto E, Semotok C, Andrysek J, Basir O. An Intelligent Diabetes Software Prototype: Predicting Blood Glucose Levels and Recommending Regimen. Diabetes Technology & Therapeutics. 2000;2(4):569-576. Coaut

D. Research Support

2015 (Principal Investigator)cant. Developing manufacturing, distribution and a fitting model for the LCKnee, a functional and affordable artificial knee joint technology for low and middle income countries. Grand Challenges Canada. Phase II – Transition to Scale. PI: Andrysek, Jan. 405,000 CAD. [Industrial Grants]

2015 (Principal Investigator). Developing manufacturing, distribution and a fitting model for the LCKnee, a functional and affordable artificial knee joint technology for low and middle income countries. Ontario Centers of Excelence. Market Readiness. PI: Andrysek, Jan. 125,000 CAD. [Industrial Grants]

2013 (Principal Investigator). Advancing mobility rehabilitation treatments and technologies. Canada Foundation for Innovation (CFI) (includes contributions from Ministry of Research and Innovation and Industry). John R. Evans Leaders Fund. PI: Andrysek, Jan. 135,000 CAD. [Grants]

2015 - 2016 (Principal Investigator). Developing manufacturing, distribution and a fitting model for the LCKneeTM, a functional and affordable artificial knee joint technology for low and middle income countries. Ontario Centers of Excellence. Market Readiness Customer Creation Program. 22264. Collaborator(s): David Green, Brandon Burke, Emily Lutyens. 125,000 CAD. [Grants]

2012 - 2013 (Principal Investigator). Developing instrumentation and techniques to assess the biomechanical performance of SideStix high-performance crutches and other commonly used upper body ambulatory aids. NSERC. Engage. EGP 436728-12 / Fund # 493917. PI: Andrysek, Jan. Collaborator(s): SideStix. 24,918 CAD. [Grants]

2012 - 2017 (Principal Investigator). Mobility assistive technologies for human locomotion. Natural Sciences and Engineering Research Council of Canada (NSERC). Discovery. RGPIN 401963. 125,000 CAD. [Grants]

2012 - 2013 (Principal Investigator). A novel artificial knee joint for lower-limb amputations: a functional and affordable technology for low and middle income countries. Grand Challenges Canada. 2nd Round of the Canadian Rising Stars in Global Health comp. #0048-01-04-01-01. 100,000 CAD. [Grants]

2011 - 2012 (Co-Principal Investigator). A pilot study to explore the short-term impact of acute physical fatigue on sensory, motor and cognitive processes in ambulatory youth with cerebral palsy. BRI - Université Laval Research Chair in Cerebral Palsy Collaborative. Catalyst Grant Competition. PI: Andrysek J (co-PI). 22,500 CAD. [Grants]

2010 - 2012 (Co- Principal Investigator). Evaluation of proshetic alignment methods for improving the biomechanics and mobilty of individuals with transtibial amputations. Sunnybrook Health Sciences. Practice-based research award for the health disciplines. PI: Andrysek J (co-PI). 11,873 CAD. [Grants]

2009 - 2010 (Principal Investigator). Development of an injection mouldable prosthetic knee joint technology. Ontario Centers of Excellence. Market Readiness. MR 40095-09. 29,895 CAD. [Grants]

2009 - 2010 (Principal Investigator). Refinement of prototype for self-energizing prosthetic knee damper. Ontario Centers of Excellence. CCIT Market Readiness. MR10108-08. 50,000 CAD. [Grants]

2008 - 2009 (Principal Investigator). Further development of the self-energizing prosthetic damper. Ontario Research Commercialization Program. Proof of Principle Fund (ORCP - POP). 25,000 CAD. [Grants]

2008 - 2009 (Principal Investigator). Effect of the Wii Fit video game as a therapeutic intervention in promoting dynamic balance-control among paediatric amputees. Bloorview Research Institute. Seed Grant Competition. PI: Andrysek J (co-PI). 24,525 CAD. [Grants]

2008 - 2009 (Principal Investigator). Further development of a stance-phase controlled knee-ankle-foot-orthotic. Ontario Research Commercialization Program. Proof of Principle Fund (ORCP - POP). 50,000 CAD. [Grants]

2008 - 2009 (Principal Investigator). Swing-phase controller for a low-cost prosthetic knee joint. Ontario Research Commercialization Program. Proof of Principle Fund (ORCP - POP). 49,000 CAD. [Grants]

2007 - 2008 (Principal Investigator). Development and clinical testing of a low-cost prosthetic knee joint. Canadian Institutes of Health Research (CIHR). Proof-of-Principle Phase I. 200704PPP. 129,510 CAD. [Grants]

2007 - 2008 (Principal Investigator). Evaluation of the effectiveness of paediatric prosthetic technologies. Bloorview Research Institute. Seed Grant Competition. 24,991 CAD. [Grants]

2007 - 2008 (Collaborator). Assessment of spinal stability in children with pediatric spinal deformities. Bloorview Research Institute. Seed Grant Competition. PI: Zabjek K. 24,287 CAD. [Grants]

2007 - 2008 (Principal Investigator). Self-energizing prosthetic damper. Canadian Institutes of Health Research/ Natural Sciences and Engineering Research Council of Canada/ Social Sciences and Humanities Research Council. Medical Technol. Research & Commercialization Collaborative. 20,000 CAD. [Grants]

2006 - 2007 (Principal Investigator). Design and development of a stance-phase controlled knee-ankle-foot-orthotic. Canadian Institutes of Health Research (CIHR)/Health Technology Exchange. HTX - CIHR R&D Program. 100,000 CAD. [Grants]

2006 - 2007 (Principal Investigator). Preliminary design and evaluation of a sealed myolelectric hand. Bloorview Research Institute. Seed Grant Competition. 24,954 CAD. [Grants]

2006 - 2007 (Principal Investigator). Development of a low-cost prosthetic technology. Canadian Institutes of Health Research/ Natural Sciences and Engineering Research Council of Canada/ Social Sciences and Humanities Research Council. Medical Technol. Research & Commercialization Collaborative. 13,333 CAD. [Grants]

2005 - 2006 (Principal Investigator). Design and testing of an adult version of the SupPORT knee. Canadian Institutes of Health Research (CIHR). Health Technology Exchange. 84,173 CAD. [Grants]

2005 - 2006 (Principal Investigator). Design and development of a paediatric orthotic knee joint. Bloorview Children's Hospital Foundation. 19,984 CAD. [Grants]

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors in the order listed on Form Page 2.
Follow this format for each person. **DO NOT EXCEED FOUR PAGES.**

NAME	POSITION TITLE
Swarup, Arushri	Graduate Student Institute of Biomaterial & Biomedical Engineering, University of Toronto
eRA COMMONS USER NAME (credential, e.g., agency login)	

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	MM/YY	FIELD OF STUDY
Institute of Biomaterial & Biomedical Engineering, University of Toronto		06/16	Biomedical Systems Engineering

NOTE: The Biographical Sketch may not exceed four pages. Follow the formats and instructions below.

A. Personal Statement

The objective for my MASc Master's research project is to develop improved endoscopic ear surgery instruments. Relevant experience gained through my undergraduate degree in Biomedical Systems Engineering at the University of Toronto and my internship at a medical device company will enable the success of this project. During my internship of 16 months at Baylis Medical Company, I designed and tested manufacturing processes and tools for a mechanical medical device. I built up skills in 3D modeling software and basic machining to develop prototypes that were tested and further improved through team collaboration. In order to ensure the tools and processes were easy to use and successfully built functional devices, I worked with a team of engineers as well as the users of the tools during development. For my final year design project, I used these skills to develop a functional, initial prototype of an instrument to facilitate graft removal from a Rosen Needle. Therefore, these skills have and will enable me to design robust final prototypes that are functional and reliable for surgical use.

B. Positions and Honors

C. Selected Peer-reviewed Publications

D. Research Support

RESOURCES & ENVIRONMENT

Follow the 398 application instructions in Part I, 2.7 Resources.

The project will be completed at established facilities available within the University of Toronto, including the Centre for Image Guided Innovation and Therapeutic Intervention (CIGITI) at the Hospital for Sick Children (http://www.cigiti.ca), the Surgical Skills Centre (SCC) at Mount Sinai Hospital (http://sites.utoronto.ca/ssc/index.html) and the Institute of Biomaterial and Biomedical Engineering (IBBME). These facilities provide the dedicated equipment and expertise required for the project and are within 3 minutes walking distance of each other. All have been successfully used by the investigators in a pilot project developing a graft positioning tool for endoscopic ear surgery.

CIGITI is an open source prototyping and engineering facility located inside the Hospital for Sick Children which specializes in the development of medical devices, surgical tools and medical robotics. The CIGITI lab will provide bench space, and machines for 3D printing, metal milling and laser etching for manufacturing prototype instruments. The IBBME will provide office desk space and computer based technologies including computer assisted design and 3D modeling software necessary for designing the instruments. The SSC is set up for temporal bone courses organized by the Department of ORL-HNS at the University of Toronto, including courses run by the primary investigator (see http://orlped.com/ear-courses). This facility will be used for testing instrument prototypes in cadaveric temporal bone models – which are readily available through the Department of Anatomy.

Laboratory staff at CIGITI will be available to provide technical support with machining as required and share experience with development of miniaturized robotic instruments. The SSC staff will set up temporal bone surgical facilities as required. The primary investigator will provide guidance on surgical ergonomics, functional requirements of instruments and feasibility of design proposals. Guidance will be based on experience form more than 10 years of endoscopic surgery with the benefit of who 2 days per week of protected time for research and education, plus funding for travel to present results. Previous related experience includes development of instrumenation for minimally invasive cochlear implant surgery and reporting of resultant patient outcomes. Dr Andrysek has supervised multiple graduate students through MASc programs at the Department of Biomedical Engineering. Funds from the grant will be used to support an MASc graduate student from IBBME to work entirely on the project within this ideal environment.

MAJOR EQUIPMENT: List the most important equipment items already available for this project, noting the location and pertinent capabilities of each.

CIGITI: Technology for production of surgical instruments and models: commercial and industrial grade 3D printing equipment (Taz5 printer, Z510 printer, Form 1+ SLA and Connex 350/500), high speed CNC micro-machining capabilities, industrial robots (Denso VP-6), 3D scanners.
IBBME: Technology for pre-production design of instruments: CAD software (Solid Works); analysis software (MatLab).
Surgical Skills Centre: Equipment for testing of instruments: rigid endoscopes, camera and monitor; operating microscope; temporal bone holders and otologic surgical instruments

Program Director/Principal Investigator (Last, First, Middle): James, Adrian Lewis

CHECKLIST

TYPE OF APPLICATION *(Check all that apply.)*

☒ NEW application. *(This application is being submitted to the AOS for the first time.)*

☐ RESUBMISSION of application number: _____
(This application replaces a prior unfunded version of a new, renewal, or revision application.)

☐ RENEWAL of grant number: _____
(This application is to extend a funded grant beyond its current project period.)

☐ REVISION to grant number: _____
(This application is for additional funds to supplement a currently funded grant.)

☐ CHANGE of program director/principal investigator.

Name of former program director/principal investigator: _____

☐ CHANGE of Grantee Institution. Name of former institution: _____

☐ FOREIGN application ☐ Domestic Grant with foreign involvement List Country(ies) Involved:

INVENTIONS AND PATENTS *(Renewal appl. only)* ☐ No ☐ Yes

If "Yes," ☐ Previously reported ☐ Not previously reported

1. PROGRAM INCOME ***(See instructions.)***

All applications must indicate whether program income is anticipated during the period(s) for which grant support is request. If program income is anticipated, use the format below to reflect the amount and source(s).

Budget Period	Anticipated Amount	Source(s)
	$0.00	NA

2. ASSURANCES/CERTIFICATIONS ***(See instructions.)***

In signing the application Face Page, the authorized organizational representative agrees to comply with the policies, assurances and/or certifications listed in the application instructions when applicable. Descriptions of individual assurances/certifications are provided in Part III and listed in Part I, 4.1 under Item 14. If unable to certify compliance, where applicable, provide an explanation and place it after this page.

3. FACILITIES AND ADMINSTRATIVE COSTS (F&A)/ INDIRECT COSTS. See specific instructions.

PLEASE NOTE: The AOS limits indirect costs to 10% of the total award for Clinical Grants, Research Grants, and Research Fellowships. For the Clinician-Scientist Award, indirect costs are limited to 8%. The indirect costs should be calculated into the budget so that the total does not exceed the maximum allowed for the award. You are encouraged to briefly explain the need for indirect costs in the space below.

Explanation *(Attach separate sheet, if necessary.):*

Indirect costs of 10% as specified by Research Institute, Hospital for Sick Children = $4,767

This section of the NIH application pertaining Disclosure Permission Statement is not needed for the AOS applications.

RESEARCH PLAN – (not to exceed 12 pages – See instructions/table of contents)

Specific Aims

The overall goal of this project is to develop and test new surgical instruments that are well-suited to the specific needs of surgeons practising endoscopic middle ear surgery. To achieve this goal the specific aims are to:
1. conduct a needs assessment to understand the functional limitations of currently available otologic surgical instruments as used in endoscopic ear surgery
2. to utilize the findings of the needs assessment to define design criteria upon which a design will be developed and prototyped
3. to evaluate the performance of the prototype instruments

There has been a surge in interest over recent years in the use of rigid endoscopes for otologic surgery, particularly for tympanoplasty and cholesteatoma surgery (1). It has been found that endoscopic surgery can improve outcomes by enhancing minimally invasive access for disease eradication and reducing post-operative morbidity (2-4). Despite the enthusiasm of some otologists, endoscopic ear surgery has not as yet been accepted by all practicing otologists (5). One of the principle barriers to adoption of this new approach is that surgery must be completed with one hand, as the non-dominant hand is typically required to hold the endoscope (5-7). This can be challenging as most otologic instruments and techniques have been developed for use with two hands and an operating microscope. A static endoscope holder is not a feasible alternative to allow two-handed surgery, as positioning of the endoscope is necessarily dynamic to optimize the view and accommodate instrument positioning. We propose that new instrumentation can be developed specifically for one-handed endoscopic surgery to overcome the limitations of current instruments. By overcoming this barrier to progress in the field of endoscopic surgery, the advantages of minimally invasive surgery will be accessible to more otologists to the benefit of patients with chronic ear disease.

Research Strategy

Significance

Surgical instruments used in middle ear surgery today have been developed and selected over the course of the last century. The range of instruments available has been strongly influenced by the working conditions provided by the operating microscope, in which the surgeon is able to operate with both hands and requires a direct line of sight to the surgical field. Surgical techniques as well as instruments have evolved around these operating conditions. For example, an external incision is often required to provide adequate visualization and access for instruments from both hands. When access is not available to hidden recesses within the tympanomastoid system, bone of the mastoid, ear canal and even ossicular chain is removed to provide a direct line of sight. Reconstruction techniques often rely on two hands to position and stabilise grafts and prostheses. Throughout middle ear surgery, the non-dominant hand is often used to suction blood from the field and retract soft tissue during dissection. As otologists have been trained and gained experience in such techniques with such instruments, they have become accustomed to a two-handed surgical approach.

Although first reported in the 1990s (6, 8, 9), there has been a surge in enthusiasm for endoscope-guided ear surgery over the last 5-10 years, particularly for the minimally invasive benefits of totally endoscopic surgery (1). As clear access to the tympanic membrane and recesses of the tympanic cavity can be achieved without an external incision, the patient benefits from a reduction in post-operative morbidity (10). (Complications such as wound infection and keloid scar have been reported in 4% of surgeries with a post-auricular incision (2)). More effective disease control has been shown with reduction in rates of residual mesotympanic cholesteatoma (2, 3) and better hearing from ossicular preservation (10, 11). Despite these obvious advantages to the patient, the advent of endoscopic ear surgery has not been met with universal enthusiasm in the otologic community (5). As described above, one of the principle barriers to adoption of totally endoscopic surgery is that as one hand is used to hold the endoscope, only one hand is available to operate. By learning different surgical techniques and gaining experience with the endoscope, most surgeons find that they can complete a larger and larger proportion of tympanoplasty and cholesteatoma surgeries endoscopically (1, 7, 12). Nevertheless, the learning curve can be slow and frustrating. In the experience of the primary investigator (PI), technological advances have lead to incremental stepwise jumps in this learning curve. Examples of beneficial technologies include high definition cameras and monitors, 3mm diameter endoscopes and suction dissection instruments (13). With the benefit of these technologies and lessons learned from colleagues in the field, over the course of 10 years, the PI's use of endoscopes in cholesteatoma surgery has increased from inspection after microscope-guided dissection, through endoscope-guided dissection via an external incision, to totally endoscopic tympanoplasty, cholesteatoma removal with cartilage reconstruction and ossiculoplasty. Despite these advances and the long learning curve, it is only over the last year that a significant majority of the PI's cases have been completed totally endoscopically (unpublished prospective data).

Currently only a limited selection of instruments is available for endoscopic ear surgery. One set of instruments, known as the IWGEES set (Karl Storz GmbH & Co. KG; Tuttlingen, Germany) was developed from the work of Thomassin (9). From discussions with colleagues in the field and personal experience, it is recognized that limitations of these instruments include suction cannulae that are too narrow leading to frequent occlusion and flexible instability, and small-tipped dissectors and picks that rarely reach requisite recesses within the ear. The round knife has an unusually flat angle from the shaft of the instrument that is widely considered suboptimal. An innovative set developed by Panetti (13) incorporates suction into dissection instruments with an ingenious rotating connector (Spiggle & Theis Medizintechnik GmbH; Burghof, Germany). Although providing valuable benefit in clearing blood from the field during dissection, criticisms of these instruments have included: the thumb control for suction which rotates out of reach when the instrument is manipulated; dissection tips which are too pointed; lumen of the suction not reaching the cutting edge of the round knife; longer curved dissectors lacking the delicacy required for small recesses. It is the understanding of the PI that both sets of instruments were developed according to the ideas and suggestions of individual surgeons without wider consultation in the design process. From discussion with industry representatives, the expense of manufacturing development and marketing have been deterrents to revision of the design to suit more widespread requirements.
In order to overcome the limitations of one-handed surgery, current instrumentation and the slow learning curve to transition to this minimally invasive technique, innovations in the design of otologic instruments are required to make instruments more fit for purpose. This project seeks to contribute a significant incremental benefit to the practice of endoscopic ear surgery by refining instrument design to be optimized for endoscopic use, particularly for cholesteatoma surgery. It is anticipated that more widespread uptake and application of totally endoscopic ear surgery will improve patient care, particularly in the fields of cholesteatoma surgery and tympanoplasty (6). An innovative research and development approach to instrument creation based on wider consultation with modern engineering design principles and rapid-prototyping will be implemented.

Innovation

This application seeks to shift current clinical practice in surgery for chronic middle ear disease by creating novel instrumentation that will facilitate the practice of endoscopic ear surgery. Practitioners of endoscopic ear surgery will be surveyed to reveal the barriers they faced when adopting the technique, and that they continue to experience in endoscopic ear surgery. A comprehensive assessment of existing instruments, including intra-operative time-flow analysis, will be used to identify potential design limitations of currently available instruments that. Innovative solutions to these barriers will be developed including on-line focus-group based discussions, concentrating on enhancing multi-functionality of instruments to be operated easily with one hand.

While decades of evolution in instrument design have lead, in the large part by trial and error, to the "survival" of the effective tools surgeons use today, it is proposed that new surgical instruments can be developed more efficiently by harnessing the power of modern computer assisted design (CAD) and rapid template prototyping. Virtual temporal bone models can be created from computerized tomography (CT) scans to test the reach and compatibility of CAD model instruments alongside the endoscope within the ear canal. 3D printing and metal milling machines can be used to rapidly create solid models of temporal bones and instruments to test prototype instruments before moving to the more restrictive testing environment of the operating room or even temporal bone laboratory. The feasibility of this methodology has very recently been tested by the members of this research team in the development of a novel instrument for positioning soft tissue tympanic membrane grafts endoscopically.

Research Approach

The project comprises three distinct parts toward the development of novel surgical instrumentation for endoscopic ear surgery: (1) to complete a needs assessment, (2) to design and prepare instrument prototypes, and (3) to evaluate the prototype instruments. The basis of this grant application is to support a graduate student from the MASc program at the Institute of Biomaterial and Biomedical Engineering (IBBME) University of Toronto for these purposes.

1) Needs assessment

The needs assessment will comprise two separate parts: (a) a time-flow analysis in the operating room of the PI and (b) a survey of endoscopic ear surgeons' experience.

a) Time-flow analysis

Time-flow analysis is an approach used to breakdown and quantify the period of time associated with the completion of a particular task; it is used across a variety of fields, including medicine (14). The MASc student from the IBBME will observe endoscopic ear surgeries and note the time taken to accomplish pre-determined steps in the surgery. Broadly, these will be divided into preparation, tympanomeatal flap elevation, access to tympanomastoid sub-sites for cholesteatoma removal, graft positioning, and ossiculoplasty. The type of instruments used during these different maneuvers and the number of changes between different instruments will also be noted. These observation will also lead to an appreciation of the ergonomic requirements of instruments during otologic survey and the design advantages of different instruments for specific maneuvers.

It is anticipated that variance in time-flow between cases will be high between cases based on patient specific factors such as extent of bleeding, ear canal morphology, extent of disease. Nevertheless, this methodology will provide a more accurate assessment of surgical practice and challenges than anecdotal surgeon's recall. Steps demanding a disproportionate amount of time or multiple changes in instrument will be determined from analysis of these data. This will reveal procedural areas in which surgical efficiency may be improved by instrument modification.

b) Survey

A qualitative assessment of the challenges in endoscopic ear surgery caused by limitations in current instrumentation will be completed by performing an on line survey of surgeons that perform endoscopic ear surgery.

Open-ended questions based on the personal experience and time-flow analysis of the PI will be generated and piloted on a subset of six other otologists known to have varied experience in endoscopic ear surgery within the University of Toronto. Questions will ask for comments on factors that have prevented otologists from using endoscopes in otologic surgery, and for comments on the perceived strengths and weaknesses of currently available instruments for endoscopic ear surgery. Responses to these questions will be used to design the survey which will also include open-ended questions to capture the breadth of different experiences within the field. The survey will be provided electronically using FluidSurveys, an online survey tool (http://fluidsurveys.com).

Participants for the wider survey will be recruited by email and personal communication from the PI, and will include the 60 members of the International Working Group on Endoscopic Ear Surgery (IWGEES) (http://www.iwgees.org) plus delegates that have attended courses organized by the PI and consenting members of the IWGEES. Involvement in the survey will be anonymized to encourage accurate disclosure of surgeons' challenges. Responses to the survey will be collated to find common themes.

A high response rate to the survey is anticipated, as the IWGEES members are well known to the PI and enthusiastic supporters of positive innovations in the field.

An open-coding thematic content analysis procedure will be applied to the data (15, 16) whereby the three investigators will independently review each response, coding line by line while noting key themes and patterns in the needs or functional requirements that the instrument should satisfy. The investigators will compare and contrast the themes and their relationships amongst each other. Any discrepancies will be resolved through discussion amongst all investigators. Using an iterative process, codes will then be organized according to those with similar meanings (15, 16).

From the PI's personal experience and prior communication with IWGEES members and participants of Endoscopic Ear Surgery Conferences worldwide, it is anticipated that the following challenges and needs will be revealed:

- Difficulty clearing blood from the field
- Difficulty retracting soft tissue flaps during dissection
- Access to deeper recesses of the middle ear cleft that are revealed by endoscopy, but beyond the reach of conventional instruments
- Difficulty with bone removal beyond atticotomy curettage
- Difficulty with graft positioning.

Factors such as these will be combined with emphasis given to those reported most frequently by survey respondents to generate a list of requirements for improvements in endoscopic surgical instrumentation. The list of requirements from the survey will be combined with the summary of the time-flow data to determine areas of greatest need for instrument improvement.

Surgeons previously contacted for the survey will be sent copies of the findings and invited to offer suggestions for improvements in instrument design. It is anticipated that the response rate to this request may be low as surgeons may be protective of their own ideas, but may still help to generate some innovative solutions. Any solutions offered will be combined with concepts already developed by the research team to generate innovative designs for novel instrumentation. The strengths and weaknesses of current otologic instruments will be included in this review and attention paid to combing functions of current instruments into single tools that can be simply operated with one hand.

The strength of this methodology is that opinion will be sought widely in order to develop instruments that meet the needs of a large number of surgeons. A potential weakness would be a lack of adequate or representative responsiveness from survey participants. However, the creation of practical and innovative solutions to the challenges of endoscopic surgery is not dependent upon a high survey response rate. Having taught at multiple surgical courses, participated in seminars, attended endoscopic conferences around the world, and by associating with other leaders in the field, the PI has considerable insight into the current status of activity and opinions within the field of endoscopic ear surgery.

2) Instrument design and preparation

To facilitate the translation of the functional requirements established as part of the needs assessment, well-accepted design methodologies will be applied. One such technique termed 'Quality Function Deployment' (QFD) utilizes a matrix format for establishing the relationships amongst various needs or functional requirements (what the device needs to do) and the design parameters (how the device will do it). The QFD approach affords a systematic approach for mapping the requirements to design parameters, that will result in the most effective solution (17-19). The technique has been successfully applied in the past by co-applicant (JA) in the development of assistive technologies (20).

Once the design parameters have been established design concepts will be generated during a brain storming session that will involve the team of co-investigators having expertise in the areas of mechanical engineering and surgery. The design process will follow well-accepted principles and guidelines for generating and evaluating ideas and concepts, and translating them into viable designs (21). Subsequently, to aid the design process and development of the detailed designs, from the experience of the PI and feedback from the needs analysis will be used to create virtual models of instruments will be developed with computer assisted design software (Solid Works; Dassault Systèmes Solidworks Corp, Waltham, MA, USA). The dimensions and curvature of instruments will be optimized to reach the relevant areas of the middle ear cleft via the ear canal alongside a rigid endoscope. Virtual models of the temporal bone will be created from clinical CT scans of patients with cholesteatoma to create accurate testing scenarios. Scans will be selected in preference from cases in which current instrumentation proved inadequate, for example cholesteatoma in a deep sinus tympani or tympanic membrane reconstruction with a curved or narrow external auditory meatus.

Designs showing promise in the virtual testing environment will be prepared using 3D printers when possible for speed and economy of production. Instruments requiring resolution finer than that which is achievable from available printers will be prepared by milling surgically compatible metals (eg surgical steel, Nitinol) and modifying pre-existent surgical instruments as necessary. Prototypes will then be tested in conjunction with rigid endoscopes on 3D printed temporal bones, including those prepared in house from the virtual models described above and on commercially available models (Phacon GmbH, Leipzig, Germany) to allow comparison with standardized cases. Semi-synthetic graft material (eg: Biodesign, Cook Medical Inc. Bloomington, IN, USA), silastic ear plug putty (previously utilized in house as a non-biohazard model for cholesteatoma matrix), and ossicular replacement prostheses (eg: Kurz TORP, Instrumentarium, Terrebonne, QC, Canada) will be manipulated using the prototype instruments within the printed temporal bones as models for tympanoplasty graft positioning, cholesteatoma removal and ossiculoplasty respectively. Designs will be modified according to early experience with prototypes in these testing environments.

No significant obstacles are anticipated for this stage of the project. Successful implementation of design concepts into working prototypes is anticipated as identical methodology has recently been used by the research team for production of a graft positioning tool for endoscopic surgery. This preliminary work is summarized briefly in the section below. Also, the PI has reported previously on clinical utility of 3D printing of temporal bones (22) and validation of temporal bone models for otologic assessment (23-25). The PI also has experience of development of novel surgical instrumentation for minimally invasive cochlear implant surgery (26) and has followed up with reporting of outcomes from successful implementation of this innovation (27-31).

3) Instrument testing

Having produced working prototypes, otologic colleagues will be invited to assess the instruments in printed temporal bones and cadaveric temporal bones. Participants in this evaluation will include the PI and six additional staff otologists within the University of Toronto who have agreed to participate, plus volunteers from interested otology fellows and residents. It is anticipated that at least 10 surgeons will participate in this stage of instrument evaluation. Participants will be asked to evaluate their endoscopic ear surgery experience as nil / limited / more extensive.
Instruments will be tested using the simulated surgical procedures described above, and evaluated on a 10-point scale covering: ease of use with endoscopy in the model, perception of fitness for purpose, how significantly the instrument would increase the proportion of cases that the surgeon could complete endoscopically, and desirability for making the instrument available for use in clinical practice. Recommendations for improvements in design will be sort. Responses will be de-identified so as to minimize bias in reporting.
This small sample of evaluators includes surgeons with minimal (as well as extensive) endoscopic experience as it is considered important to include those who have not as yet adopted endoscopic surgery into their practice because of limitations in one-handed techniques and available instruments. Additional feedback will be sought from otologists experienced in endoscopy at forthcoming courses and conferences.

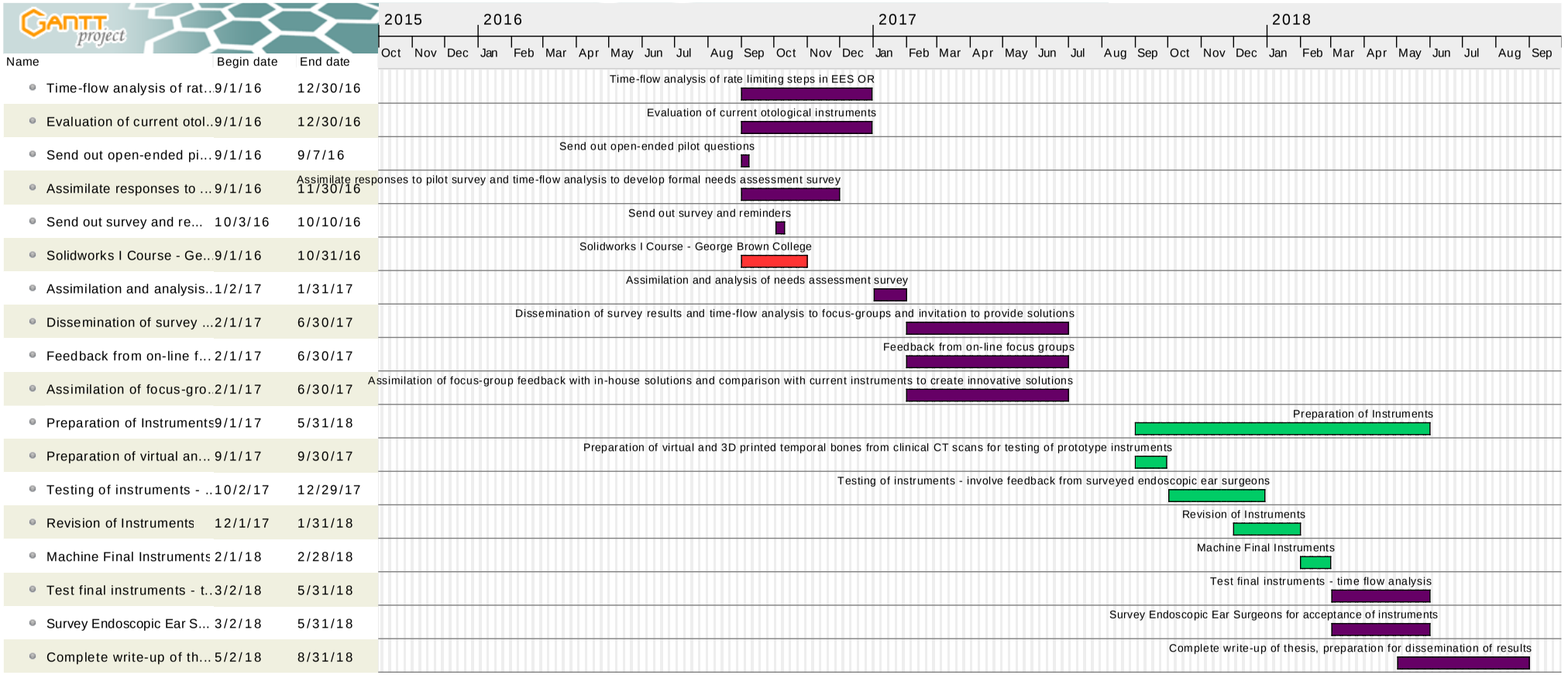
Instruments that are considered safe and suitable to utilize in the operating room will then be evaluated by the PI in patients according to the hospital policy on surgical innovation.

A guide to the anticipated time line of the project is outlined in Figure 1.

Endoscopic Ear Surgery Tool Development Timeline

Jan 26, 2016

Gantt Chart



Dissemination of findings and translation to surgical practice

The findings of the study will be submitted for presentation at the earliest opportunity at international conferences, and grateful acknowledgement made to any grant awarded by the American Otological Society. The work will be summarized and submitted as an MASc thesis through the IBBME at University of Toronto and reports of the needs assessment and instrument development and evaluation submitted for publication in peer-reviewed otolaryngologic journals.
It is the intention of the PI and research team to make instruments developed by this project available for widespread surgical practice. An industrial partner will be sought to facilitate commercial development. An industrial partner has not been sought for the initial stages of this project as it is considered commercial imperatives would not support the detailed investigative approach required for thorough assessment of needs and search for innovative solutions. Care will be taken to protect intellectual property rights: it is anticipated that this will be a necessary precaution for an industrial partner to protect the costs of commercial development, marketing and distribution. According to the terms of engagement of members of the research team with their host institutions, intellectual property rights will belong to the University of Toronto and /or Hospital for Sick Children and managed through the MaRS partnership (https://www.marsdd.com) in order to support development of the technology. The PI and members of the research team have no financial interest in this project and no conflict of interest.

Preliminary Studies for New Applications

As detailed above, the previous publications of the investigators report experience using QFD methodology for optimizing translation of functional assessment into design, development of otologic surgical instruments and evaluations with temporal bone models (20, 22-31).
The investigators have recently collaborated on a successful pilot project to develop a novel instrument to facilitate one-handed manipulation of soft tissue grafts in tympanoplasty surgery. A needs assessment based on intra-operative observations and discussions between the PI and co-investigator (AS) with fellow undergraduates lead to the computer assisted design (at the IBBME), 3D printing and Nitinol milling (at CIGITI) of a working prototype. The instrument was evaluated by three otologists and otolaryngology residents in a dry model (3D printed bone with synthetic graft material) and wet temporal bone (at the Surgical Skills Centre). Recommendations for further refinement were made and are in process. The successful completion of the pilot study and the enthusiastic feedback of the evaluators provided the inspiration for the comprehensive project described above. The unique combination of relevant surgical and engineering experience with dedicated specialist infrastructure within one institution demonstrate the viability of the project as proposed.

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