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ORIGINAL ARTICLE

The acceptance and adoption of transoral robotic surgery in Australia and New Zealand

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Abstract

Transoral robotic surgery (TORS) provides improved access to head and neck subsites resulting in well-validated functional and oncological outcomes, but access to and cost of robotic platforms can limit their use. Evidence suggests TORS is increasingly being adopted globally, but there is a paucity of data on the adoption and diffusion of TORS in Australia and New Zealand. A cross-sectional analysis was performed. An online survey was distributed to otolaryngologists and head and neck surgeons through three different Australian and New Zealand specialty membership databases. A 5-point Likert scale based on a Unified Theory of Acceptance and Use of Technology (UTAUT) model was incorporated to assess barriers and facilitators to adoption. 77 respondents completed the survey. 43.6% of head and neck surgeons had performed TORS. The most common cases were lateral oropharyngectomy (35.9%), base of tongue resection (33.3%), tongue base mucosectomy (28.2%), supraglottic laryngectomy (15.4%) and TORS for obstructive sleep apnoea (12.8%). Perceived barriers to adoption were high costs, access to and availability of the robotic platform and limited training opportunities. This study provides evidence of adoption of TORS in Australia and New Zealand; however, there is a perception that significant barriers to adoption persist. Results from this study may help guide decisions on how we train and license surgeons in the era of this technology.

Keywords Robotics · Survey methodology · Otorhinolaryngologic surgical procedures · Minimally invasive surgical procedures · Head and neck neoplasms

Introduction

Transoral robotic surgery (TORS) was first described in 2005 and has since become an established approach for oropharyngeal squamous cell carcinoma (OPSCC) [1–4]. It provides minimally invasive access through the natural orifice of the mouth with a magnified field of view, three-dimensional, high-resolution optics, and elimination of human tremor and de-escalation of robotic arm movements. Large prospective case-series have demonstrated well-validated functional and oncological outcomes for its use in head and neck squamous cell carcinoma (HNSCC) [5–7].

Expense of and access to the robotic platform have been prominent limitations. In Australia, the da Vinci has an estimated installation cost of AUD $3.25 million, a AUD $100,000 annual maintenance fee, and disposable costs of around AUD $2000 per case [8, 9]. The limited number of platforms, and the theatre space a unit occupies, often results in administrative decisions to share the robot amongst surgical subspecialties, impeding its day-to-day availability. Haptic feedback for tumour palpation has yet to be rolled out. While randomised control trials are underway, there is currently no high-level evidence to demonstrate superiority of robotic over non-surgical approaches in HNSCC treatment [10–12].

Despite this, robotic head and neck surgery is increasingly being performed internationally [13]. Robotic approaches have been applied to a wide range of head and neck subsites and conditions including surgery of the skull-base,

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parapharyngeal space, thyroid gland and cervical lymph nodes along with most mucosal subsites [14–18].

There is currently no data on TORS adoption and diffusion in Australia and New Zealand. Given the competing advantages and limitations of this technology, and the emergence of new robotic platforms designed specifically for head and neck surgery such as the Flex® Robotic System (Medrobotics corporation, Raynham, MA, USA), [19, 20] we sought to understand the current level of use and perception of robotic head and neck surgery in our jurisdiction to better guide state-level and national decisions about training, accreditation, research and hospital funding. The objectives of this study were to analyse: (1) demographic and geographic characteristics of TORS surgeons, (2) the number and types of cases performed and (3) surgeons perceptions of the facilitators and barriers to adoption of TORS.

Methods

Study design

A cross-sectional study was conducted. All procedures followed were in accordance with the ethical standards of the Royal Adelaide Hospital committee on human experimentation and with the Helsinki Declaration of 1975, as revised in 2000 (5). Informed consent was obtained from all participants for being included in the study.

An on-line questionnaire was created using SurveyMonkey (SurveyMonkey Inc., San Mateo CA). Surgeon demographic information, including age, gender, scope of practice and practice setting as well as exposure to TORS was recorded. Surgeons' perception of robotic technology was assessed with a set of 28 questions answered on a 5-point Likert scale developed from a Unified Theory of Acceptance and Use of Technology (UTAUT) model (Online Resource 1) [21–23]. Questions fell into five domains of 'performance and effort expectancy', 'social influence', 'facilitating conditions', 'attitudes towards use' and 'leadership' (Fig. 1a) and the possible responses on the scale were scored from − 2 to + 2. This data provided the foundation for drawing conclusions about the adoption of this technology.

Data acquisition

The survey was distributed to surgeons via email through the membership databases of three societies: The Australian Society of Otolaryngology, Head and Neck Surgery (ASOHNS), The New Zealand Society of Otolaryngology, Head and Neck Surgery (NZSOHNS) and the Australia and New Zealand Head and Neck Cancer Society (ANZHNCS). Distribution commenced in October 2016, a reminder email was sent at 1 month, and closure of the portal occurred after 2 months. Responses were anonymous and the software prevented duplicate entry.

Statistical analysis

Complete responses were tabulated and expressed as percentages. Incomplete responses were excluded. Weighted averages were calculated for questions answered on the 5-point Likert scale using SurveyMonkey software and displayed on weighted average graphs.

Results

Demographic results

The survey was distributed to over 450 otolaryngologists or head and neck surgeons. The exact number of surgeons was unable to be determined as some recipients had membership across more than one of the three different society databases. There were 77 complete responses included in the analysis, out of a total of 111 responses (77/111 (69%) completion rate). The maximum calculated response rate was 77/450 (17%). Overall, 66/77 (85.7%) of respondents were male and 11/77 (14.3%) female. The majority (32/77, 41.6%) were in the age range 41–50 years, followed by 31–40 (18/77, 23.4%), 51–60 (16/77, 20.8%) and > 60 (11/77, 14.3%). No respondents were under 30. The majority had practiced as a consultant for > 10 years (41/77, 53.3%), followed by 5–10 years (20/77, 26%). Equal numbers had practiced as a consultant for 1–3 years and 5–3 years (8/77, 10.4%). All but two had primary otolaryngology training, with one trained primarily in plastic surgery and another in general surgery. Overall, 39/77 (50.6%) indicated they specialized in head and neck surgery. Of these, 30/39 (76.9%) described their practice as including some transoral surgery, while 9/39 (23.1%) reported having a focus on transoral surgery. There were 36.7% (28/77) who were general otolaryngologists and 13% (10/77) combined who sub-specialized in otology, rhinology, laryngology and paediatric otolaryngology. There were 89.6% (69/77) who worked in a university-affiliated hospital and 57.1% (44/77) in the private sector. Most responses in Australia were received from Queensland (17/77, 22.1%), then New South Wales and Victoria (13/77, 16.9% each), South Australia (8/77, 10.4%), and Tasmania and the Australian capital Territory (1/77, 1.3% each). There were 21/77 (27.3%) responses from New Zealand (Fig. 1b).

Exposure to robotic surgery

Overall, 27.3% (21/77) of respondents had performed robotic surgery. Of the 39 head and neck surgeons, 43.6% (17/39) had performed robotic surgery (Fig. 1c). In a

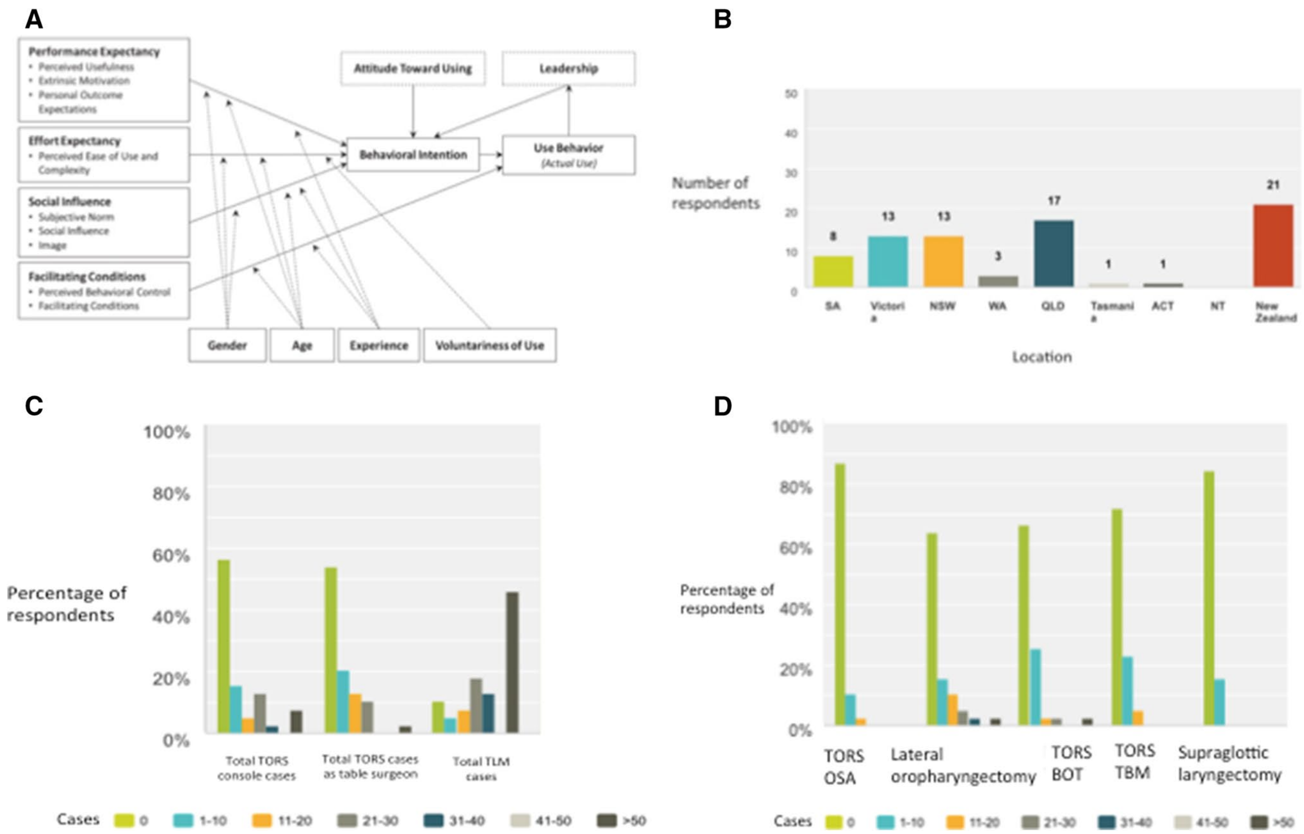

Fig. 1 **a** A diagram representing how the core domains described in the Unified Theory of Acceptance and Use of Technology (UTAUT) model interplay with technology-user-specific factors such as gender, age, etc. to ultimately affect behavioral intention and actual use. **b** Geographic distribution of respondents. **c** Comparison of Head and Neck Surgeons' exposure to TORS (as console surgeon or table surgeon) and TLM. **d** Breadth of TORS procedures performed by Head and Neck Surgeons. *TORS* transoral robotic surgery, *TLM* transoral laser microsurgery, *OSA* obstructive sleep apnoea, *BOT* base of tongue, *TBM* tongue base mucosectomy

subgroup analysis of these 39 respondents, 6/39 (15.3%) had performed 1–10 cases, 5/39 (12.8%) had performed 21–30 cases, 2/39 (5.1%) had performed 11–20 cases and 1/39 (2.6%) had performed 31–40 cases. There were 3/39 (7.7%) who performed greater than 50 robotic cases. In contrast, 35/39 (89.8%) had performed transoral laser microsurgery (TLM), with 18/39 (46.1%) performing greater than 50 cases.

The TORS cases performed most commonly by head and neck surgeons were: lateral oropharyngectomy (14/39, 35.9%), base of tongue resection (13/39, 33.3%), tongue base mucosectomy (11/39, 28.2%), supraglottic laryngectomy (6/39, 15.4%) and TORS for obstructive sleep apnea (5/39, 12.8%) (Fig. 1d). Of the less commonly described TORS operations, 4/39 (10.3%) performed TORS oral cavity surgery, 2/39 (5.1%) performed TORS total laryngectomy, 1/39 (2.6%) performed robotic assisted neck dissection (RAND), 1/39 (2.6%) performed pediatric robotic head and neck surgery and 1/39 (2.6%) performed nasopharyngectomy. No respondents had performed robotic thyroid surgery.

Performance and effort expectancy

There were seven statements in the 'performance and effort expectancy' domain with results illustrated in Fig. 2a.

Social influence

There were seven statements in the 'social influence' domain with results demonstrated in Fig. 2b.

Facilitating conditions

There were ten statements in the 'Facilitating conditions' domain with results demonstrated in Fig. 2c.

Attitudes towards use

In response to the statement "I have high expectations of robotic surgery", 6/77 (7.8%) strongly agreed, 35/77 (45.5%) agreed, 32/77 (41.6%) were neutral and 4/77 (5.2%) disagreed with a weighted average of 3.56. Most

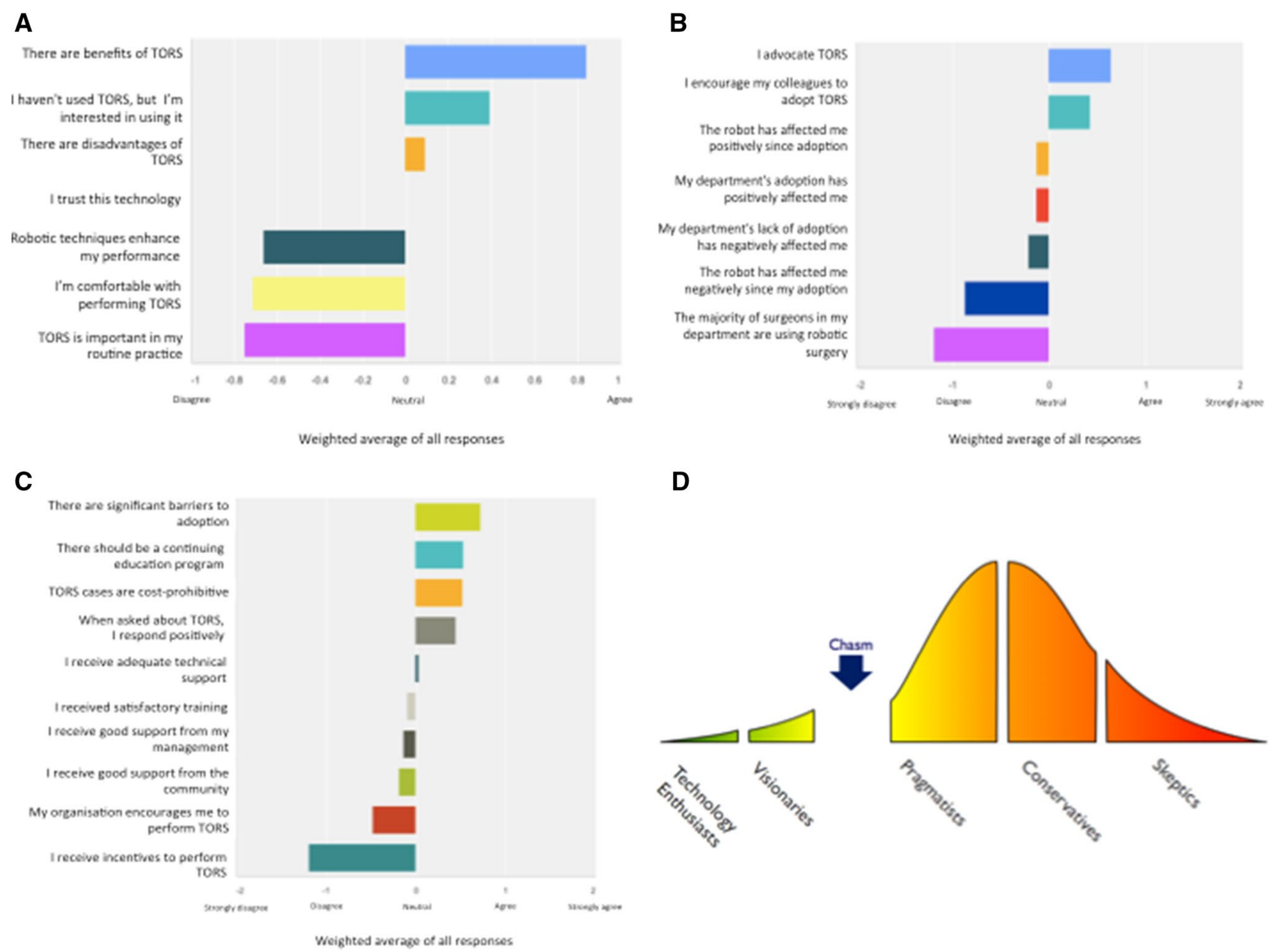

Fig. 2 **a** A graph demonstrating the weighted average of all responses to questions asked in the domain of 'Performance and effort expectancy'. **b** A graph demonstrating the weighted average of all responses to questions asked in the domain of 'Social influence'. **c** A graph demonstrating the weighted average of all responses to questions asked in the domain of 'Facilitating conditions'. **d** Diagrammatic representation of the 'Technology adoption cycle', including the chasm described by Moore [27] that separates the visionaries (early adopters) and the pragmatists (early majority)

respondents were inclined to agree this technology needed to be widely accepted before they were willing to adopt it into their practice (weighted average 2.82).

Leadership

Respondents tended to disagree that they were involved in their organisations decision to adopt robotic technology (7/77 (9.1%) strongly agreeing, 16/77 (20.8%) agreeing, 14/77 (18.2%) neutral, 25/77 (32.5%) disagreeing and 15/77 (19.5%) strongly disagreeing). The majority responded affirmatively supporting their organisations adoption (14/77 (18.2%) strongly agreeing, 29/77 (37.7%) agreeing, 23/77 (29.9%) neutral, 5/77 (6.5%) disagreeing and 6/77 (7.8%) strongly disagreeing).

Discussion

This is the first study to analyse the adoption and diffusion of robotic surgery in Australia and New Zealand, with results demonstrating evidence of TORS adoption. TORS lateral oropharyngectomy and base of tongue resection were the most commonly performed procedures. Surgeons in Australia and New Zealand are performing less commonly reported and more technically challenging procedures including robotic assisted nasopharyngectomy, total laryngectomy and paediatric TORS procedures.

To understand the process of how new medical technology spreads through clinical practice, health economists model data on sociological theories [24]. The diffusion of innovations theory proposes three variables that influence dissemination of technology: (1) how it is perceived, (2) the characteristics of people who adopt it and (3) the environment into which is being adopted [25, 26]. A bell curve has been used to demonstrate the adoption cycle with the early tail of the curve representing the innovators or 'technology enthusiasts', followed by the early adopters or 'visionaries', the early majority or 'pragmatists', the late majority or 'conservatives' and finally, the laggards or 'skeptics' (Fig. 2d) [27]. It is postulated that the most difficult step in this cycle is between the early adopters and early majority, and that only by crossing the chasm between these two consumer groups can a product become de facto, or in the case of health technology, a standard of care (Fig. 2d) [27].

The UTAUT model was developed by unifying the technology acceptance literature and was recently contextualized to understand the facilitators and barriers to adopting robotic surgery in a study by BenMessaoud et al. [21] This model serves to understand the social, psychological and behavioral factors that impact a surgeon's intentional or voluntary use of robotic technology and can help guide clinical and administrative decisions [22, 23].

To date two studies, both from the United States, have sought to understand the adoption and diffusion of TORS based on these sociological theories. Chen et al. undertook a retrospective review of the US NCDB of all adults with OPSCC treated between 2010 and 2011 and demonstrated a 67% increase in the use of TORS in this period [28]. TORS utilization increased rapidly in academic centers and community centers and was associated with a lower rate of positive margins than non-robotic surgery [28]. Cracchiolo et al. retrospectively reviewed the US NCDB from 2010 to 2013 for cases of T1–3 OPSCC treated with surgery and found a 28% TORS utilization [13]. Low tumour stage, treatment at an academic center and treatment at a high volume hospital were associated with an increased TORS approach [13].

In the present study, there was an adoption rate of 43.6% among head and neck surgeons suggesting that TORS in Australia and New Zealand has crossed the chasm between the visionaries and the pragmatists on the technology adoption curve. Diffusion was more prominent in major capital cities and in university-affiliated hospitals. This could reflect concentration to high volume centers with greater surgeon and institution experience [13, 28]. The effect of tumour factors on TORS approach cannot be commented upon as tumour T-stage and margin status were not outcomes sought in this study.

There is no NCDB in Australasia, so this study used a survey design to obtain data. An advantage was that data on robotic procedures for indications other than OPSCC could be obtained, allowing for the analysis of robotic technology utilization across the full spectrum of described robotic head and neck procedures. Surgeon demographics could be obtained, which has not previously been analysed, and is a variable of the diffusion of innovations theory. Incorporation of a UTAUT model allows us to understand how technology is perceived and the environment into which it is being adopted. A limitation of the voluntary survey is that it is vulnerable to sampling error and respondent bias. Privacy and confidentiality requirements prevented acquisition of specific institution and patient data. This cross-sectional study will need to be repeated to understand trends in adoption and diffusion over time.

TORS accreditation requirements have been an area of contention. The American Head and Neck Society (AHNS) education committee currently reports no standardization of training and credentialing of TORS in the US [29]. In Australia, ASOHNS has clearly defined guidelines for the use of TORS, with ongoing accreditation currently requiring a surgeon to have performed a minimum of 20 procedures a year, of which a least 10 should be as the primary console surgeon. This study found 11 respondents who had performed more than 10 TORS console cases and revealed a perception that robotic surgery is inaccessible. Relaxing annual case requirements and ensuring technical maintenance with stringent continuing personal development requirements may help to overcome this.

Training in TORS was another flagged barrier. Currently there is no national standardization and a graded curriculum to develop competency in preclinical models prior to clinical transition, as described in the US, may help to overcome this barrier [30]. Furthermore, this survey could be sent to registrars to help guide the design of a structured curriculum for junior trainees, similar to programs implemented at the University of Pennsylvania and Johns Hopkins Hospital, which increase early exposure to this approach [31, 32].

Cost of robotic surgical technology and support from hospital administration were perceived limitations, although recent studies suggest TORS is a cost-effective approach with lower use of adjuvant chemoradiation, lower rates of late gastrostomy and tracheostomy dependence and lower overall treatment related costs of care [33, 34]. Discordance between public opinion and recent research provides impetus for local TORS cost-benefit analyses, and education campaigns. It is plausible that market competition from the introduction of new commercial robotic devices, will drive down costs, increasing platform availability, and resulting in improved training, surgeon experience, advances in techniques and, ultimately, better patient care. However, the assumption that lower cost newer robotic platforms can bridge the gap of cost and access is not validated. Studies evaluating the cost-utility of robotic surgery have thus far been exclusively performed on the da Vinci platform and, therefore, a study to show comparative results with newer platforms would be ideal. Regardless, effective collaboration with hospital administration will continue to be a crucial component to the uptake of this technology.

While the data from this study has been obtained from Australia and New Zealand, the issues raised in this can be extrapolated to other countries. Furthermore, it was our intention that other jurisdictions could replicate the survey methodology used in this study based on the Unified Theory of Acceptance and Use of Technology (UTAUT) model to evaluate the acceptance and adoption of TORS in their own areas. Within the limitations of a voluntary survey design, this study suggests that TORS has crossed the chasm in the technology adoption cycle that separates the visionaries from the pragmatists, and has become an accepted approach for the management head and neck disease. There is a strong perception that cost, availability and training barriers remain and potential systems to overcome this have been discussed, including creating more achievable accreditation standards and incorporating a structured curriculum for junior trainees. It is the imperative of leading head and neck surgeons to reach consensus on how best to tackle these challenges and then to work with surgical and non-surgical colleagues, hospital administration and industry to implement positive change. Experience of the early adopters and the mindset of this surgical community will shape the adoption curve in the coming decade and further studies will be required to understand the trends in diffusion of robotic technology over this time.

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Compliance with ethical standards

Conflict of interest Dr. Giri Krishnan, Dr. Jack Mintz and Mr. Andrew Foreman declare that they have no conflict of interest.

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