Robotic surgery for otolaryngology

B Acar¹*, RM Karasen²

Abstract
Introduction
The invasion of robotic technology in surgical fields cannot be ignored. Safe use of the robotic platform has been successfully demonstrated in all types of head and neck procedures; however, price remains controversial. The majority of studies are retrospective, and suggest outcomes that are similar to standard surgery. The aim of this critical review was to discuss the robotic otolaryngologic surgery.

Conclusion
Robotic surgical procedures appear to be associated with improved surgeon ergonomics, and have great future potential for further advancements, the current instrument size and cost limit applicability of the current robotic system.

Discussion
Transoral robotic surgery
Oropharyngeal and supraglottic cancer is not a common cancer; but it affects people over the age of 45 years who consume alcohol and smoke cigarettes or use other kinds of tobacco. For complete treatment, management is en bloc removal of the tumour which is known as prognostic for surgically managed oropharyngeal tumours. The majority of TORS cases were indicated in Stage I and Stage II diseases which are, by definition, T1 or T2 tumours. Conventional transoral surgery is the most challenging operation due to suboptimal target visualisation. In the past, this operation was done by open surgery in which neck incision has to be performed and had significant operation-related complications. Recently, in a few centres in the world, this operation was done by endoscopic surgery (conventional endoscopy) and a growing number of cases were done robotically in Europe and America. The console surgeon views a 3D magnified image and controls the instruments which perform multi-planar, en bloc resection. Most importantly, estimated less blood loss (EBL) reduced the tracheotomy rate, a shorter length of hospital stay and improved functional outcomes have been reported. Neck dissections are almost always necessary in this population, and most studies are routinely staged 1–3 weeks following the primary site TORS procedure.

Radical tonsillectomy
Robot-assisted radical tonsillectomy was first described in 2007 by Weinstein et al.⁶. It has since enjoyed widespread adoption at many high-volume centres. Recent evidence suggests that TORS radical tonsillectomy offers local regional control of 97% and disease-free survival of 90% while providing the additional benefit of shorter hospital stay, less intra-operative EBL, a high rate of early return to oral intake without enteral supplementation and a low rate of percutaneous endoscopic gastrostomy (PEG) tube retention⁷. In an analysis of 27 TORS radical tonsillectomy cases, surgical margins were histologically negative in 25 patients⁸.

Tongue base resection
Some physicians have found robotics to be useful in treating obstructive sleep apnoea and identifying the tumour in patients with unknown primary carcinoma via robotic-assisted lingual tonsillectomy and partial glossectomy⁹.¹⁰. In 2012, Vicini et al. performed tongue base reduction in 20 patients with obstructive sleep apnoea or

¹ Corresponding author
Email: drbarnacar@gmail.com

¹ Keçiören Training and Research Hospital
² Hacettepe University Department of Otolaryngology, Head & Neck Surgery, Hacettepe University Faculty of Medicine, Ankara, Turkey

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snoring. The authors concluded that this study reported a reduction in apnoea/hypopnoea index (AHI) and Epworth Sleepiness Scale after 10-months follow-up.  

The base of tongue (BOT) resection via TORS for the treatment of patients with obstructive sleep apnoea (OSAS) is significantly effective in improving AHI. The mid-term data are encouraging and worthy of further investigations but increased morbidity compared with the other techniques studied.

Transoral robotic cordectomy

Some authors have reported the use of CO₂ laser fibre and the Da Vinci robotic platform for the surgical management of a T1 glottic squamous cell carcinoma.

Kayhan et al. reported their initial experience in 10 patients, securing their airway without a tracheotomy who underwent transoral robotic cordectomy. One subject needed a flexible CO₂ laser with TORS has been reported in one patient with T1 glottic laryngeal tumours squamous cell carcinoma.

Proponents argue that the robotic technique allows increased degree of mobility of the TORS instrumentation, no line-of-sight limitation, improved instrumentation and flexible laser fibres, and that TORS will continue to develop and be one of the significant tools in the surgical armamentarium in the treatment of early laryngeal tumours.

Supraglottic laryngectomy

Transoral vocal cord surgery seems to have overtaken through an external approach, namely by partial laryngectomy as the treatment of choice due to patient preference for minimally invasive surgical options. Patient intrigue coupled with aggressive marketing of robotic surgery means that the robotic-assisted technique allows a scarless in the neck approach. Robot-assisted supraglottic laryngectomy is rapidly gaining acceptance in the otolaryngologic community as a safe and efficacious treatment option for supraglottic laryngeal cancer with comparable oncological outcomes as external approach and transoral counterparts. TORS supraglottic laryngectomy has come a long way since the first large series appeared in the literature (Figure 1), and a recent analysis by Park et al. found that TORS supraglottic laryngectomy provided acceptable rates of short-term oncologic outcomes, swallowing and voice outcomes without a permanent stoma for supraglottic laryngeal cancer. This study was especially promising as it included a large number of patients for analysis and demonstrated that when an experienced and well-trained surgeon performs TORS supraglottic laryngectomy. Newly emerging evidence reinforces this point, with TORS supraglottic laryngectomy having higher rates of improved access and teachability than transcervical partial laryngectomy and transoral laser microsurgery (TLM). However, the University of Pennsylvania has not yet published their 5-year data.

In one of the largest studies to date, Park et al. found that the methods stated by Weinstein et al. achieved comparable oncological outcomes to conventional supraglottic partial laryngectomy, but TORS offered rapid functional recovery and less morbidity compared with conventional supraglottic partial laryngectomy. Furthermore, the methods stated by Weinstein et al. utilised the increased dexterity of the robot’s wristed instruments and high magnification 3D view to ensure permission en bloc resection, which conferred the resection margins better which is an important factor for determining whether adjuvant therapy is indicated as compared with TLM. The aforementioned results were corroborated in a meta-analysis from various high-volume centres, which revealed that TORS supraglottic laryngectomy had better return of swallowing and improved voice function postoperatively than after open modalities. Positive margin rates after TORS in this study of 177 patients were found to be 4.3%. TORS also seemed to have decreased intra-operative blood loss, risk of intra-operative transfusion and the tracheotomy dependency rates in comparison with external approach. Coupled with the fact that TORS seems to have a shorter learning curve than external approach and

Figure 1: Surgeons perform a transoral robotic surgery supraglottic laryngectomy.
Transoral counterparts, it appears that the use of robotic surgery in the realm of localised laryngeal carcinoma will reach even greater heights.

Total laryngectomy
Smith et al. have described usage of robotic equipment for transoral total laryngectomy in five of the seven patients owing to the excellent visualisation and maximal mucosa-sparing resection.

Techniques and applications of transcervical surgery
Transaxillary thyroidectomy
The transaxillary robotic technique was first demonstrated in 2005 for a hemithyroidectomy in a paediatric patient by Lobe et al.17. In one of the largest studies to date, Kang et al. found the gasless transaxillary technique. In 2009, they reported their experience of 581 cases for patients with thyroid cancer via two incisions. In an effort to further reduce the invasive nature of this surgery, the robotic thyroidectomy via a single axillary incision is described and evaluated by Chung et al. This approach was also used to perform lobectomy, parathyroidectomy, total thyroidectomy and neck dissection in patients with pathologic nodal disease.

Following axillary incision, a working space is created in the plane between the strap muscles and the pectoralis major muscle up to the clavicle. The robotic instruments are then placed into the field and the thyroid is removed.

More recently, the robotic transaxillary approach to the thyroid gained acceptance in the United States as a safe and feasible treatment option for selected thyroid cases.

The surgeons noted that the obvious advantage of the robotic-assisted thyroidectomy through the axilla is the avoidance of a cervical scar. Additionally, possible added benefits relate to decreased length of hospital stay and improved dexterity. However, several limitations were reported. Surgical times for the new approaches are significantly longer than traditional thyroid surgery. In addition, some potential complications that do not occur during open procedure must be considered because of the lateral approach, including injury to the carotid artery, brachial plexopathy, jugular vein and oesophagus.

Facelift or retroauricular approaches
Recently, Terris et al. have described robotic-assisted thyroidectomy approaches such as the facelift approaches may also overcome these limitations by approaching the thyroid from above. They have published their study on a series of 18 patients with no complications.

Parotidectomy, submandibular gland excision and neck dissections via a facelift approaches have also been described successfully in the literature. The surgeons noted that facelift or retroauricular approaches has proven to be feasible, easier than transcervical access methods, and safe.

Learning curve
The standard method for teaching includes patient care, clinical workload and training. Robotic surgery has a less steep learning curve in comparison with endoscopic surgery in other specialties. Lee et al. advised in prospective multi-centre study of robotic thyroidectomy that trainees should have an experience of 50 cases for the learning curve for total thyroidectomy.

The newest generation of the da Vinci surgical robot (Si) has even more potential as a teaching tool. It has an option for an integrated two-console station. These two consoles allow for two separate surgeons to be involved in a procedure. Some major Robotic Surgical Institutes have an established training programme in TORS.

Limitations of robotics
Initial cost of equipment and cost of reusable robotic instruments is the biggest limiting factor for robotic surgery. Robotic otolaryngologic surgery has to set up at large hospitals that have performed with the assistance of a robot for other clinical applications of robots in surgery to overcome the high price.

Despite a reduction in the size of the original instruments they are still large for ENT surgery. Others believe that theatre space required to facilitate the use will be needed to accommodate the extra space requirements of robotic surgical systems.

The lack of tactile and haptic feedback is also a limitation of robotic surgery although this may contribute to the longer initial operating times and the relatively steep learning curve.

Future developments
The current surgical trend is to expand the variety of skull base regions. Several surgeons performed cadaver studies. The absence of bone cutting or drill instruments is also a major limitation, which may prevent use of this approach when bony margins or intra-cranial access is required. Therefore, surgeons at many centres are intriguing single-port surgery and multi-backbone snake-like approach. By this approach, the anatomic constraints of the head and neck structures can be accessed with ease. Early clinical trials have reported the feasibility of these techniques in helping to perform cochlear implantation.

At Johns Hopkins, Some initial studies have shown that the inclusion of high fidelity sensors may be the remedy to the lack of haptic feedback.

Conclusion
Robotic surgery is a significant advance in the realm of otolaryngologic surgery especially for head and neck cancer. More recently, the robotic transaxillary approach to the thyroid gained acceptance in the United States as a safe and feasible treatment option for selected thyroid cases. The surgeons noted that the obvious advantage of the robotic-assisted thyroidectomy through the axilla is the avoidance of a cervical scar. Additionally, possible added benefits relate to decreased length of hospital stay and improved dexterity. However, several limitations were reported. Surgical times for the new approaches are significantly longer than traditional thyroid surgery. In addition, some potential complications that do not occur during open procedure must be considered because of the lateral approach, including injury to the carotid artery, brachial plexopathy, jugular vein and oesophagus.
cancers. Robotic surgery is associated with precision and ease in dissection, incision with less steep learning curve in comparison with endoscopic surgery in other specialties. It provides all benefits of minimally invasive surgery. At present, cost is a prohibitive factor. Robotic surgery is going to stay and is going to open new avenues for image guided and tele-surgery.

Abbreviations list

AHI, apnoea/hypopnoea index; EBL, estimated less blood loss; TLM, transoral laser microsurgery; TORS, transoral robotic surgery; 3D, three dimension.

References


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