Robotic surgery for use in head and neck cancer has shown promising results in numerous applications.

Robotic-Assisted Surgery in the Head and Neck
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Background: Robotic surgery was first used in medicine in the 1980s for laparoscopic surgery. Since then, several developments have been made in the use of robotic surgery for patients with head and neck cancer.

Methods: A review was performed of the literature on robotic surgery in patients with head and neck cancer. The various sites of application are discussed in depth as well as the functional and oncological outcomes associated with the most common application of transoral robotic surgery (TORS).

Results: Robotic surgery has been used in all aspects of head and neck surgery. The results from early studies of TORS have shown at least equivalent functional and oncological outcomes.

Conclusions: Robotic surgery has feasible utility in patients with head and neck cancer; moreover, in several circumstances it may provide superior cosmetic, functional, and oncological outcomes than conventional methods.

Introduction
Robotic surgery was first used in medicine in the 1980s for laparoscopic surgery.1 The National Aeronautics and Space Administration has also played a role in the development of robotic surgery in its efforts to advance telepresence medicine.1 The da Vinci Surgical System (Intuitive Surgical, Sunnyvale, California) was granted US Food and Drug Administration approval for select head and neck tumors after studies demonstrated the safety and feasibility of transoral robotic surgery.2

Using the da Vinci Surgical System, the surgeon can operate on a patient from a seated console with 3-dimensional (3-D) visualization and articulating instruments. For head and neck surgery, a 0- or 30-degree binocular endoscope is typically placed in the center with a 5-mm articulating EndoWrist instrument (Intuitive Surgical) on each side (Fig). The use of robotic surgery may help eliminate hand tremor while providing a magnified 3-D view of the surgical field. The proximity of the tip of the endoscope to the area of interest avoids line-of-sight challenges that may arise with the use of an operating microscope. Other advantages include the avoidance of external incisions through the use of transoral approaches, improved functional outcomes, a reduced need for tracheostomy and gastrostomy, decreased blood loss, and shorter hospital stays.3,4

Disadvantages of robotic surgery include the high financial cost and the size of the console and robotic cart. Setup time for robotic surgery can also lead to prolonged operative times; however, these times are significantly decreased with surgeon experience.5 Few patients are not candidates for transoral robotic surgery (TORS) due to anatomical limitations. Factors such as retrognathia, a full complement of dentition, trismus, macroglossia, or a small oral stoma, may prevent the introduction of the robotic arms. Recently,

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mandibular osteotomies have been advocated to improve exposure.5

Robotic surgery was increasingly used during the last decade for procedures in various surgical subspecialties, including otolaryngology. With the added widespread availability in operating rooms, many studies have described novel applications of the surgical robotic system for both benign and malignant processes of the head and neck.

Applications by Anatomical Site

Oropharynx
Surgical access and visualization of the palatine tonsils, pharyngeal walls, and tongue base can be improved with robotic surgery. The Feyh–Kastenbauer retractor is commonly used to expose the oropharynx; however, the Crowe–Davis mouth gag can also provide access. A 0- or 30-degree stereoscopic endoscope is placed in combination with a 5-mm EndoWrist Schertel or Maryland grasper in the nondominant hand; a 5-mm spatula cautery is placed in the dominant hand. Radical tonsillectomy and lateral oropharyngectomy have been described for use in tumors without bone invasion, carotid involvement, prevertebral fascia invasion, or those that involve more than 50% of the tongue base.7,9 Resection of tongue base neoplasms without the need for mandibulotomy or tracheotomy has been described with robotic surgery.7

Carcinoma of unknown primary origin is a challenge that may lead to increased treatment toxicities when exhaustive diagnostic efforts have failed. Transoral robotic resections of the tonsils and base of the tongue have been described as a new therapeutic and diagnostic paradigm with superior detection rates than traditional endoscopy.10-12

Parapharyngeal Space
Transoral robotic approaches have been used to provide direct access to the parapharyngeal space for tumors without poststyloid extension in proximity to the constrictor muscles or mucosa.13 Although this approach may help avoid neck incisions or mandibulotomy, an increased rate of unintentional capsule violation may occur as well as pharyngeal mucosal dehiscence.14 This can be of particular importance for recurrent pleomorphic adenomas following the transoral approach for which salvage surgery may require a wide resection of the involved mucosa, thus necessitating free-flap reconstruction.

Hypopharynx
Park et al15 described patients with early hypopharyngeal cancer and intact vocal cord mobility who underwent transoral robotic hypopharyngectomy and had no significant complications. When TORS and conventional open surgery for hypopharyngeal cancer were compared, a trend toward improved survival rates and a significant improvement in functional outcomes were seen with TORS.16

Larynx
Early supraglottic and glottic larynx cancers have been removed with the surgical robotic system. The endoscope and articulating instruments of the da Vinci system can also provide the surgeon access to tumors unreachable with a CO2 laser.17 Transoral total laryngectomy has also been described for patients who require salvage laryngectomy to improve wound healing without violating the integrity of the strap muscles; however, prior low tracheostomy may make distal access difficult.18

Thyroid
Thyroidectomy can be performed with the surgical robotic system and has the added benefits of improved cosmesis, decreased sensory changes, and decreased voice and swallowing discomfort.19 Avoiding cervical incision is possible through a transaxillary approach. However, the use of the robot for this approach is associated with increased operative times, the need for a working incision in the axilla or anterior chest wall, and the possibility of brachial plexus injuries.20 Robotic facelift thyroidectomy offers excellent cosmetic results and relatively easier patient positioning without the significant morbidities of the transaxillary approach.21
Neck
Robotic selective neck dissection via the postauricular face-lift approach may be used for patients with clinically N0 tumors. Similar rates of complications and significantly improved cosmetic satisfaction rates were seen in patients undergoing the aforementioned approach compared with conventional open neck dissection. Similar to robotic thyroid surgery, this procedure should be reserved for the subset of patients for whom cosmetic satisfaction is important because of its significantly increased operating time and cost.

Skull Base
Transoral robotic approaches to the skull base can be combined with endoscopic techniques to expose the posterior skull base, nasopharynx, and the infratemporal fossa. The traditional endoscopic endonasal approach combined with a robotic approach complement each other due to the difficulty of endoscopic access below the hard palate and eustachian tube; in addition, the robotic system lacks a drill to remove bone.

Unknown Primary Origin
Mehta et al used robotic surgery in the workup of patients with unknown primary origin of head and neck cancer. They were able to identify up to 90% of primary tumors by resecting the base of the tongue following negative formal endoscopy with biopsy and tonsillectomy. Using a robotic system to perform limited tongue base resection has minimal morbidity and may significantly limit the amount of radiation patients receive.

Outcomes

Functional
Definitive radiotherapy with or without chemotherapy for patients with head and neck carcinomas offers the possibility of organ preservation and obviates many of the morbidities associated with traditional surgical intervention. Organ preservation does not translate into organ function, which can be seen in long-term speech, swallowing, and quality-of-life scores. Early TORS has had excellent functional outcomes.

The swallowing function of most patients returns to baseline following TORS. Hurtuk et al reported that all of the participants in their study returned to an oral diet on postoperative day 1. Genden et al found that patients who underwent TORS had better swallowing scores 2 weeks following surgery than patients undergoing chemoradiotherapy (CRT). Twelve months after treatment, the researchers found that study volunteers assigned to the TORS group also returned to baseline function faster and had higher functional scores than those assigned to definitive CRT. Moore et al found that 88% of study participants returned to normal swallowing, but those who did not had advanced stage tumors and had lower pre-operative function. Weinstein reported that all participants in their study who had advanced oropharyngeal carcinomas returned to normal swallowing function following TORS.

The rate of gastrostomy tube dependence in patients following TORS is low compared with patients undergoing definitive CRT. Weinstein et al found that patients undergoing TORS had a gastrostomy dependence rate of 2.4% following the procedure compared with rates of 9% to 38% in patients receiving CRT. Tumor stage and synchronous primaries have been correlated with the need for the placement of a gastrostomy tube prior to adjuvant treatment.

The rate of tracheostomy dependence following TORS is low. In most cases, patients have a planned tracheostomy and are successfully decannulated. The average length of time requiring tracheostomy ranges from 1.5 to 7 days. Moore et al reported that 1 patient required permanent tracheostomy, and Weinstein et al reported that 2 patients underwent an unplanned tracheostomy and 1 patient required long-term tracheostomy for alcohol withdrawal.

Oncological
The oncological outcomes with TORS are excellent, but long-term follow-up has been short. Disease-specific rates are reported to be as high as 95% to 98%. Moore et al found that 17% of patients were treated with surgery alone and were able to avoid any additional adjuvant therapy. For patients with advanced-stage oropharyngeal carcinoma, Weinstein et al found that 11% of patients did not require adjuvant treatment; however, the majority of patients still received definitive CRT. White et al reported an overall survival rate at 2 years of 89% in a large series of patients undergoing primary TORS. All patients in the study received either adjuvant CRT or radiation alone.

An advantage to the use of TORS is the possibility of therapy deintensification, which could result in the reduced incidence of the long-term adverse events of definitive CRT. Genden et al compared 30 patients undergoing TORS with a control group of 26 patients receiving CRT. Disease-free and overall survival rates at 18 months for the TORS group were 78% and 90%, respectively; the CRT group had disease-free and overall survival rates of 88% and 100%, respectively. The locoregional control was comparable. Thirteen patients who, based on initial clinical staging, would have required definitive CRT had chemotherapy withheld and a reduced total radiation dose to 60 Gy. Pathological staging allowed for 24% of patients in the TORS group to avoid adjuvant chemotherapy.

Future Studies
Researchers from the Radiation Therapy Oncology Group are studying TORS for the surgical intensifica-
tion of the treatment of human papillomavirus (HPV)-negative oropharyngeal tumors and the de-escalation of chemoradiation in HPV-positive oropharyngeal tumors (NCT01953952). The objective of the trial is a 15% reduction of progression-free survival in HPV-negative tumors using TORS and pathologically guided adjuvant therapy.

A trial conducted by the Eastern Cooperative Oncology Group is measuring the progression-free survival rate, locoregional recurrence, and functional outcomes of patients who are HPV positive and undergoing TORS (NCT01898494). Patients with stage N1/N2b will be observed. Those with stage 3/4 tumors undergoing TORS will be further randomized based on pathological findings. Patients with close margins, 2 to 4 positive lymph nodes, lymphovascular invasion, perineural invasion, and less than 1 mm of extracapsular spread will receive radiation doses of 50 or 60 Gy. Those with positive margins, more than 5 positive nodes, and those with more than 1 mm of extracapsular spread will receive cisplatin and a radiation dose of 66 Gy.

Conclusions

The development of robotic surgery for use in head and neck cancer has shown promising results in varied applications. The feasible use of the robotic system has been demonstrated in many aspects of head and neck surgery. Transoral robotic surgery has expanded the armamentarium of treatment modalities focused on reducing the functional deficits while also maintaining excellent oncological outcomes. Patient selection has been an important factor in initial studies as not all patients are candidates for robotic surgery. Thus, the widespread adoption of the robotic system for use in patients with head and neck cancers will help clarify the indications for use of the robotic surgical system and its correlated outcomes.

References


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