Robotic Surgery
A New Approach to Tumors of the Tongue Base, Oropharynx, and Hypopharynx

Etern S. Park, DDS, MDa, Jonathan W. Shum, DDS, MDa, Tuan G. Bui, MD, DMDa,b, R. Bryan Bell, DDS, MDa,b,c,d, Eric J. Dierks, DMD, MDa,b,c,*

INTRODUCTION

When Mr DF, a singer and bass guitar player from Oregon, first learned that he had SCC of the tonsil, he was told the cancer would require a combination of chemotherapy and radiation therapy and would probably mark the end of his singing career. If he opted for traditional surgery, his jaw and tongue would need to be split and reconstructed, leaving visible scars on his lower lip and chin. The 73-year-old musician initially agreed to undergo the recommended treatment of radiation and chemotherapy. A few days later, his surgeon called to let him know about another option—robotic surgery—which could be performed through his mouth and meant that he would not have to have his jaw and tongue divided. The musician underwent surgery on March 2010 and became one of the first patients to undergo TORS for cancer on the West Coast. Two years later, he remains cancer-free and he continues to enjoy eating, singing, and performing in his band (Fig. 1).

Disclosure: All authors have no financial relationships to disclose.

a Head and Neck Surgical Associates, 1849 Northwest Kearney, Suite 300, Portland, OR 97209; Legacy Emanuel Medical Center, 2801 North Gantenbein Avenue, Portland, OR 97227, USA;
b Providence Portland Cancer Center, 4805 Northeast Glisan Street, Portland, OR 97213, USA; c Oregon Health and Science University, 611 Southwest Campus Drive, Portland, OR 97239, USA; d Oral, Head and Neck Cancer Program, Robert W. Franz Cancer Research Center, Providence Portland Cancer Center, 4805 Northeast Glisan Street, Portland, OR 97213, USA
* Corresponding author. Head and Neck Surgical Associates, 1849 Northwest Kearney, Suite 300, Portland, OR 97209.
E-mail address: eric.dierks@gmail.com

http://dx.doi.org/10.1016/j.coms.2012.11.002
1042-3699/13/$ – see front matter © 2013 Elsevier Inc. All rights reserved.
Head and neck SCC affects 500,000 people worldwide per year. In the United States, approximately 35,000 adults will be diagnosed with SCC of the oral cavity and oropharynx every year. SCC in these sites can be treated with 1 of 3 standard treatment modalities, including surgery, radiation therapy (RT), or chemotherapy, or a combination of these. Classical oropharyngeal cancer surgery consists of en bloc resection of the tumor via lip-split mandibulotomy approach and flap reconstruction, often followed by adjuvant therapy if indicated. This treatment provided good rates of locoregional disease control. The morbidity associated with the traditional surgical approach, however, and the need to reconstruct with an insensate, adynamic flap to seal tissue planes that were widely opened for surgical access frequently resulted in incapacitating deficits in speech and swallowing. This led many physicians to prefer the use of definitive chemoradiotherapy (chemoRT) without surgery.

The shift toward organ-sparing treatment began with the multicenter Veterans Affairs larynx study of 1991, which showed that chemoRT alone could achieve cure rates equivalent to laryngectomy followed by RT while preserving the larynx. This organ-sparing philosophy, and enthusiasm for chemoRT as opposed to primary surgery, extended to other sites in the oropharynx, such as the tonsil and base of tongue. Chemotherapy plus high-dose RT (70 Gy or more) became the standard of care for oropharyngeal squamous cancer. Although concurrent chemoRT offers high rates of locoregional disease control, recent attention has been given to the significant functional deficits and diminished quality of life after intense chemoRT.

MINIMALLY INVASIVE SURGERY

In the 1980s, minimally invasive surgery was introduced and rapidly spread from gynecology to general and thoracic surgery. Laparoscopic and thoracoscopy offer the advantages of small incisions, reduced blood loss, shorter hospital stays, and fewer complications. Limitations of the laparoscopic approach include loss of depth perception, replacement of natural hand-eye coordination with paradoxic instrument movement, and loss of dexterity. In the head and neck, the laparoscopic approach has few applications due to its limited surgical exposure and restrictions in movement of the instruments. Still, in 2003, the da Vinci (Intuitive Surgical, Sunnyvale, CA) system was first described as a means of minimizing incisions in the neck.

HISTORY OF ROBOTIC SURGERY

Leonardo da Vinci, the Renaissance painter and scientist, is credited for designing and building the robot in human form around in the year 1495. It was not until the mid-twentieth century that his sketches and diagrams were recognized as prototypes for modern robots. It is fitting that
the most widely used Food and Drug Administration (FDA)-approved surgical robot in today is named, *da Vinci*.

Although robots have been used in industries, such as automobile manufacturing, for decades, the first surgical robot was the Programmable Universal Machine for Assembly (PUMA), which was used for stereotactic brain biopsies and for resection of an astrocytoma of the thalamus in 1985. The United States military and the National Aeronautics and Space Administration recognized the concept of telepresence surgery, which entails the possibility of having a highly skilled surgeon available to the battlefront from a safe, remote site to perform surgery on wounded soldiers. Although telepresence surgery never found application in the military, their efforts accelerated the development of robots in medical applications today.

In 1992, the ROBODOC (Curexo Technology Corporation, Fremont, CA) was introduced in orthopedic surgery. Its role as a robot was limited to milling of the femoral cavity for hip replacement surgery. A year later, Wang developed the Automated Endoscopic System for Optimal Positioning (AESOP), which was used in laparoscopic surgery to enable surgeons to control the robotic arm and video laparoscope either manually or with a surgeon’s voice. In 1999, the ZEUS system, consisting of 3 robotic arms and a voice-controlled endoscope holder arm, was used by Reichenspurnen and colleagues for performing 2 aortocoronary bypasses. The limitations of rigid equipment and a 2-D view of the surgical field without depth perception led to development of the current da Vinci Surgical System by Intuitive Surgical. The first da Vinci surgical robot head and neck operation that was successfully performed on a human was the excision of vallecular cyst.

THE DA VINCI SYSTEM

Although robots have been described in science fiction as autonomous and preprogrammed machines, the surgical robot is neither. Conceptually, it is an extension of a surgeon’s hands and mind to the surgical field. The da Vinci system is the primary robotic system in use today in the field of medicine. It consists of 3 major components, each of which is independently mobile:

1. **The surgeon console:** The surgeon is immersed in high-definition video in 3-D for true perception of depth, allowing a virtual extension of the surgeon’s hands into a patient’s body. The surgeon’s thumb and third finger engage the hand units that control the instruments and that scale down movement to 5:1. A filtration module eliminates hand tremor. Pedals are used for cautery, for camera movement, and to clutch for optimal position of the instruments.

2. **The robotic cart:** This allows the surgeon to manipulated up to 3 EndoWrist (Intuitive Surgical, Sunnyvale, California) instruments, although only 2 are used for TORS. EndoWrist instruments provide 7° of freedom and 90° of articulation as well as tremor reduction (Fig. 2). The robotic telescope contains 2 cameras in the distal tip, which are separated by 15°. Each camera transmits an image to a different eye, allowing a truly stereoscopic view of the surgical field (Fig. 3).

3. **The vision cart:** This contains the light source and the dual camera and supports the monitor, which displays a high-definition image of the surgical field to a bedside assistant, other members of the surgical team, and observers.

The surgeon is not scrubbed and is seated at the operating console. The bedside assistant is scrubbed and is seated at the patient’s head and assists with suction and retraction. The scrub nurse and instrument table are located by the patient on the opposite side of the bedside assistant, allowing efficient communication among surgical team members and minimizing obstruction (Fig. 4).

For a TORS case, the patient is intubated orally with a reinforced endotracheal tube, which is sutured to the contralateral buccal mucosa. The patient is rotated 180° away from the anesthesiologist. The patient’s eyes are protected using an
adhesive plastic eye shield, and the maxillary teeth are often protected with dental guard. Either the McIvor retractor or the Feyh-Kastenbauer-Weinstein-O’Malley retractor is placed and rigidly secured to the operating table for optimal surgical exposure and visualization. Proper placement and fixation of the retractor are critical for success in TORS. The robot is docked at a 30° angle to the operating table. The camera arm is then positioned centrally, and arms 1 and 2 are positioned on either side of the camera arm, allowing optimal range of movement with minimal collisions. Arm 3 is not used in TORS and it is positioned out of the way (Fig. 5).

TORS INDICATIONS FOR HEAD AND NECK CANCER

Tonsil and base of the tongue resections are the most commonly performed procedures with TORS. Indications for TORS for oropharyngeal cancer are

1. The tumor must be adequately visualized and exposed for resection. Consider characteristics,
such as trismus, anteriorly positioned larynx, macroglossia, and morbid obesity, which may make retractor placement difficult.

2. The tumor must be amenable to negative margin resection with TORS.

Contraindications for oropharyngeal TORS include:

1. Tumor invading the mandible
2. Unresectability of involved neck nodes
3. Resection requiring more than 50% of the tongue base
4. Resection requiring more than 50% of the posterior pharyngeal wall
5. Radiologic confirmation of carotid artery involvement
6. Prevertebral fascia fixation of the tumor

Neck dissection may be performed concurrently or in a delayed fashion. Postoperatively, a decision is made whether to keep the patient intubated due to edema. In the authors’ institution, most patients who undergo base of tongue resection remain intubated overnight, and most who undergo radical tonsillectomy are extubated in the operating room after surgery.

**CONCURRENT NECK DISSECTION WITH TORS**

With TORS, many surgeons have avoided concurrent neck dissection, and staging of the neck dissection was preferred to avoid creating a pharyngocutaneous communication and to avoid bathing the exposed carotid artery in saliva. The addition of laryngopharyngeal swelling from concurrent neck dissection may necessitate tracheostomy. Staged neck dissection after primary tumor resection can provide additional benefits, including decreased need for tracheostomy and allowing the surgeon to readdress the primary tumor site at the time of neck dissection if the final surgical margins are positive for malignancy. Staging the neck also helps to maximize the usage of the da Vinci robot by other surgeons by decreasing the operating time of a TORS case in the robot room in a high volume institution. Weinstein and colleagues demonstrated acceptable outcomes with TORS radical tonsillectomy in 27 patients and advocated staged neck dissection in 1 to 3 weeks. Their rationale for staged neck dissection was to avoid a connection between the pharynx and the neck and to minimize neck swelling.
Staged neck dissection, however, carries an inherent financial burden and risks. It contributes to increased overall treatment cost due to multiple hospitalizations and it potentially delays recommended adjuvant therapy. Ang and colleagues and Peteras and Withers demonstrated a greater than 6-week interval between initial surgery, and postoperative RT yielded significantly lower locoregional control rates in patients receiving the 7-week scheduled RT. They recommended completion of the RT in a cumulative time of less than 13 weeks from the ablative surgery. Holsinger and colleagues reported 191 oropharyngeal carcinomas with simultaneous neck dissection. None of these patients developed pharyngocutaneous fistulas. Moore and colleagues reported on 148 consecutive patients with oropharyngeal carcinoma who underwent TORS with concurrent neck dissection. Forty-two (29%) patients had intraoperative orocervical communication, which was repaired with primary closure or pedicled locoregional muscle flap. Of these, 6 (4%) patients were managed with outpatient incision and drainage with packing. In the authors’ institution, 25 patients have undergone TORS for oropharyngeal carcinoma to date. Ten (40%) patients had simultaneous neck dissection. None of these patients had orocervical communication or required tracheotomy. TORS with concurrent neck dissection can be performed safely in many patients without delaying adjuvant therapy or compromising safety.

TORS AND QUALITY OF LIFE

Tumor control and survival rate are considered the most important measures of treatment efficacy for patients with primary oropharyngeal SCC. Studies using aggressive and uncompromised RT with concurrent chemotherapy have consistently demonstrated a survival and locoregional disease control benefit. This benefit, however, has not come without drawbacks. Levendag and colleagues demonstrated a steep dose-effect relationship, with an increase of the probability of dysphasia of 19% with every additional 10 Gy after 55 Gy in RT. In addition to dysphasia, the adverse effects associated with RT are well known to oral and maxillofacial surgeons and include trismus, osteoradionecrosis, xerostomia, and radiation dental caries.

In multiple studies, TORS demonstrated favorable surgical as well as functional outcomes. Weinstein and colleagues reported a 100% regional disease control rate after TORS and selective neck dissection for oropharyngeal carcinoma in 31 patients; 71% of those patients received RT or combined chemoRT. None of patients required permanent gastrostomy, and all patients were tolerating oral intake at 2-year follow-up. TORS has the potential to avoid the lower total health-related quality of life that has been independently associated with gastrostomy and history of RT among head and neck cancer patients. Li and colleagues, at the University of California, Davis, Comprehensive Cancer Center, reported that when head and neck cancers were treated by definitive concurrent chemotherapy and intensity-modulated radiation therapy without surgery, 44% of patients were gastrostomy tube-dependent at their 6-month follow-up. Total RT dosage more than 60 Gy to 62 Gy predicted greater than 50% probability of prolonged gastrostomy dependence. By comparison, 27 tonsillar SCC patients were successfully treated with TORS by obtaining negative final surgical margins in 93% of patients; 96% of these patients returned to oral intake without the need for gastrostomy. If oropharyngeal cancer treated with TORS results in negative margins and if none of the cervical nodes harbor metastases, postoperative RT is unnecessary. If postoperative RT is indicated after TORS surgery because of positive margins or greater than one positive cervical node, it is feasible to reduce the dose of postoperative RT, often without concurrent chemotherapy. Deintensified radiotherapy to the primary tumor site with selective doses to higher risk areas of the neck limits deterioration of swallowing function. TORS provides a function-preserving alternative treatment of oropharyngeal tumors. With less gastrostomy dependence, reduced need for tracheostomy, and less surgical morbidity, TORS provides favorable functional outcomes.

COST EFFECTIVENESS

The cost of medical care increases as technologic innovation in diagnosis and treatment develops. A new technology can become accepted as a standard of care if it improves survival rate or quality of life. If a new technology cannot improve surgical outcomes, it must demonstrate reduction in the cost of treatment to justify use of the new technology. Does TORS demonstrate an improved survival rate and quality of life to justify the increase in the cost of use of the robot? Robotic surgical system use has rapidly increased in the past few years. By 2007, approximately 800 da Vinci robots were installed in US hospitals. As of March 2012, 1615 units were performing 360,000 procedures yearly. The costs of operation are primarily determined by equipment cost, duration of operation, and length of...
hospitalization. Initial costs of TORS include the da Vinci Surgical System ($1–$2.3 million), an annual service contract ($100,000–$170,000/year), and instruments ($2000/instrument, each of which may be used for only 10 cases). If 300 cases are performed annually, the robot adds approximately $1000 per case over 7 years to cover initial da Vinci robot acquisition cost.

Operating room costs are significantly different among hospitals. A study of 100 US hospitals showed that operating room charges averaged $62 per minute (range $21.80–$133.12). Hillel and colleagues pointed out increased total operative time due to operating room setup as potentially limiting routine use of the da Vinci robot. McLeod and Melder reported the first use of da Vinci robot in laryngeal surgery in 2005. A vallecular cyst was excised without complication and the patient was discharged the same day. The total operative time was 109 minutes, 89 minutes of which was spent setting up the robot. A significant decrease in the robot setup time has been reported as experience with TORS increases. In a series of 150 patients with oral cavity or laryngeopharyngeal lesions in a high-volume institution, an average additional setup time to achieve exposure and robotic positioning for TORS was 4 minutes when compared with the exposure time for standard transoral resection. Considering the costs of increased operative time with setting up robot and equipment, the additional cost for TORS with an experienced operator is approximately $1300 per case ($1000 for robotic equipment and $300 for increased operating room time cost per case).

The main factor contributing to the higher cost per case is the initial cost of purchasing the robot. The addition of a trained TORS surgeon can create a TORS program at an institution that already has a robot that was purchased for other high-volume uses (ie, cardiac, gynecologic, or urological procedures). The addition of TORS cases adds to the value of the robot already purchased by the institution. Intuitive Surgical is the only manufacturer of a surgical robot at this time, and the cost of robotic operation may decline if there is more competition in the surgical robot market in the future. Long-term prospective oncologic outcome studies and direct cost analysis comparing TORS with other treatment modalities must be conducted for TORS to assert itself as the standard of care for selected head and neck cancer treatment.

**RISKS/LIMITATIONS**

Since Mohr and colleagues performed the first mitral valve repairs by using an early prototype of the da Vinci system in 1998, the da Vinci system has established a strong record of overall device safety. A multicenter trial at 10 US institutions showed 112 mitral valve repairs were performed with da Vinci robots safely and without intraoperative conversions to alternative surgical techniques (eg, sternotomy or thoracotomy enlargement). Has a comparable safety record has been observed in TORS?

Surgeons may have difficulty in transitioning from a wide-access, direct vision head and neck operation to telemanipulation of tissue in restricted spaces because of the potential limitation in the control of bleeding in oropharyngeal and laryngeal surgery. In TORS, the excellent visualization of surgical field and the use of monopolar and bipolar cautery instruments aid the maintenance of hemostasis. Robotic radical prostatectomy has been performed in large series of patients with low morbidity and significantly less operative blood loss than standard retropubic prostatectomy. Hockstein and colleagues conducted canine robotic surgery for evaluation of the ability to control bleeding in TORS. Both large and small vessel hemostasis was obtained with robot-controlled monopolar and bipolar cautery and small hemoclips. Large hemoclips were applied by a bedside assistant surgeon for management of large arterial vessels. Effective hemostasis can be obtained with control of both large and small vessels using hemoclips and electrocautery in TORS, and any bleeding from mucosa or muscle edges is essentially eliminated with the use of both monopolar and bipolar cautery. Excellent visualization of the surgical field through 3-D optics allows easy identification of vessels, aiding effective hemostasis with electrocautery and hemoclips.

The FDA maintains a Manufacturer and User Facility Device Experience (MAUDE) database, which documents reports of adverse events involving medical devices. Since inception of the da Vinci robot, 63 deaths associated with it have been reported. None of the deaths, however, was caused by the da Vinci surgical system. Of 63, 6 mortalities were associated with TORS, consisting of 3 patients with postoperative hemorrhage after base of tongue resection, 2 patients with pulmonary infection after partial laryngectomy, and 1 patient with unknown cause.

The University of Pennsylvania Head and Neck Surgery group simulated potential complications related to device misuse or malfunction by intentionally injuring human cadavers by gross robot device misuse. The simulation demonstrated that intact teeth could not be fractured and that forcefully impaling the skin and mucosa with
robotic instruments resulted only in superficial lacerations. The cervical spine or mandible could not be fractured. Orbits may potentially be injured by the robotic instruments; however, the safety goggles could not be broken by intentionally traumatizing them with the robotic endoscope and instruments. It seems that use of the surgical robot does not add substantial risk to transoral surgery.

TRAINING SURGEONS AND TORS PROGRAM IMPLEMENTATION

Introducing a new and complex technology to an institution involves many challenges. Resistance to change may come from hospital administration or operating room support staff or within surgical services themselves. Since the approval of the da Vinci robot for use in TORS by the FDA in December 2009, there have been no concrete guidelines to assist the introduction of a TORS program to an institution. The steps required for adaptation of any new technology include an assessment of the evidence-based efficacy of the procedure, provision of methodical education for surgeons to acquire knowledge and skills, intraoperative safety monitoring, credentialing and privileging of surgeons, and education of patients.

Richmon and colleagues at Johns Hopkins Hospital showed that a TORS program can be implemented efficiently and safely following a stepwise approach. Surgeons must attend a TORS course involving animal surgery provided by Intuitive Surgical and must complete an online program. This is followed by performing robotic procedures on cadavers and observation of live and video TORS procedures at 1 of 17 da Vinci Robot training centers in the United States. On returning to the surgeon’s institution, the surgeon prepares the TORS team by defining the team leader and dedicated bedside assistant with robotic training and establishes emergency plans in case of uncontrolled bleeding, airway compromise, or robot malfunction. A mock surgical case using a full-body mannequin can be simulated with a team consisting of a robotic surgeon, nurses, and anesthesiologist. Depending on the hospital protocol, initial live surgical procedures may be proctored by an experienced TORS-certified surgeon. Early experience at Johns Hopkins, with their first 20 TORS cases, showed an average positioning time of 38 ± 13 minutes, which includes patient positioning, direct laryngoscopy, and robot docking. They found no significant difference in setup time between the first 10 cases and the second 10 cases, which is in contrast to other reports, which demonstrated a steep learning curve with the initial setup. Richmon and colleagues and Lawson and colleagues credited a mock TORS-simulated case with a mannequin with providing an opportunity to address the details and complexities of room setup and positioning. Negative surgical margins were obtained in all 20 cases and average hospitalization time was 1.3 days. All patients were discharged on an oral diet. With stepwise preparation for the TORS program, favorable outcomes and efficiency can be achieved on program initiation.

Besides the efforts of the entire TORS team to run cases efficiently without compromising patient safety, the surgeon’s learning curve must be addressed. When a surgeon is learning a new surgical technique, inherent limitations are present that may result in outcomes inferior to what might otherwise have been obtained with an experienced surgeon. It has been reported that a surgeon must perform between 8 to 12 and as many as 200 cases to become proficient in a urological procedure with the da Vinci robot. Currently no data are available to estimate how many TORS cases a surgeon must perform to become proficient. Intuitive Surgical has introduced a surgical simulator for the da Vinci robot, but its exercises are not geared to TORS practice. Standardized competency evaluation paired with long-term oncological outcome is warranted.

TRAINING RESIDENTS

Ethical, economic, and legal concerns must be addressed within the context of the acquisition of new technical surgical skills in resident training. In 1995, the American College of Surgeons published a statement on 4 issues to be considered before a new surgical technology is applied to the care of patients: (1) Has it been adequately tested for safety and efficacy? (2) Is it at least as safe and effective as existing, proved techniques? (3) Is the surgeon fully qualified to use it? and (4) Is it cost effective? Present data support the concept that TORS can be performed safely and effectively and arguably cost-effectively. It was not until 2009 that robotic assistance became an important treatment modality for head and neck surgery. Most, if not all, of current TORS training programs are geared toward the training of attending surgeons. Unlike other surgical subspecialties, including urology, gynecology, colorectal surgery, general surgery, and cardiothoracic surgery, no training standards or competency verification has been set for the TORS surgical trainee.

Most robotic training occurs during live surgery or robotic courses on animal models. Training
with an animal model may provide familiarization with the surgical console, but it lacks the specific technical aspects of a procedure on a human patient. Training during live surgery may expose patients to the inherent risks associated with an inexperienced surgeon. Lerner and colleagues demonstrated that training with a virtual reality robotic simulator group had a similar significant improvement in both timing and accuracy score when compared with the group who only had training with the da Vinci surgical robot. The use of a virtual simulator may help surgical residents to acquire robotic skill safely before performing live robot-assisted surgery in a low-volume institution. TORS is inherently low volume and comprises a small portion of the total number of robot-assisted surgeries performed, which in turn limits the opportunity for resident TORS training. In the presence of low TORS case volume and with limited training opportunities at a TORS training center for residents, the robotic simulator can be a valuable training tool in the field of head and neck surgery.

Traditionally, the qualification to perform a procedure has been determined by the number of cases completed during training. Currently, however, there is no supporting evidence that performing a certain number of cases leads to performance of safe and efficient robotic surgery. A standardized assessment tool to measure robotic surgical skills—the Global Evaluative Assessment of Robotic Skills (GEARS)—has been developed by Goh and colleagues at Baylor College of Medicine. This showed excellent consistency, reliability, and validity in evaluating trainees’ robotic surgical expertise. GEARS is composed of 6 domains: depth perception, bimanual dexterity, efficiency, force sensitivity, autonomy, and robotic control. Even though GEARS was developed based on urological robotic procedures, evaluation criteria were not operation specific. It seems that GEARS may be useful to assess progression in resident TORS training.

Another useful tool for robotic surgery teaching is an integrated dual-console station. With a dual-console da Vinci robot, a student can perform the surgery while an attending surgeon can direct movement with visible pointers or can take over control of the robotic arms from a separate surgical console.

**FUTURE APPLICATIONS/TELESURGERY**

All current robotic surgeries are performed by a surgeon in the same operating room as the patient. In telesurgery, the surgeon operates at a significant distance from the patient. The first human long-distance operation with a robot was successfully performed by Marescaux and colleagues, who performed a cholecystectomy in which the surgeon was in New York and the patient in Paris. As with the military application of telepresence surgery, telesurgery may offer timely access for surgical treatment, especially for emergency operations in the setting of a scientific mission in a remote area or in a small rural hospital where surgeons are not readily available.

**SUMMARY**

Head and neck SCC is primarily treated with surgery or definitive chemoradiotherapy and both have shown similar locoregional disease control and overall survival. TORS has shown promising data to support that it provides better visualization and access to pharyngeal tumors via a minimally invasive approach, with comparable oncologic outcomes to traditional open surgery. More importantly, TORS offers less morbidity from the operation and a better functional outcome. The disadvantages of TORS center on its higher costs related to purchase and maintenance of the technology. Encouraging results of robotic surgery are reported, but definitive indications are yet to be determined. TORS should be prospectively compared with traditional surgical or nonsurgical options for each tumor location and stage to determine its specific role.

**REFERENCES**