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Single-Incision Transaxillary Robotic Thyroidectomy: Challenges and Limitations in a North American Population

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Abstract

Objective—We reviewed our initial experience with robotic thyroidectomy to identify challenges and limitations of this new surgical approach when applied to a North American population.

Study Design—Case series.

Setting—Academic institution.

Subjects/Methods—Retrospective review of 18 consecutive robotic thyroid lobectomies performed from February 2010 to April 2012 involving 16 female patients. Two patients underwent robot-assisted completion thyroidectomy a few months following the initial thyroid surgery, one for cancer and the other for goiter.

Results—Median age was 47.5 years (range, 18–62 years), and median body mass index was 28.7 (range, 19.4–44.5). Median thyroid nodule size was 2.9 cm (range, 1.1–4.7 cm). All but 1 case (6%) was performed successfully via single axillary incision. There was no conversion to an open approach. Median operative time was 170 minutes (range, 95–220 minutes), and median

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Author Contributions

Ho-Sheng Lin, study conception and design, performing all the surgeries, data collection and analysis, manuscript writing, manuscript preparation and submission, final approval of the version to be published; **Adam J. Folbe**, collection and analysis of data, revising the manuscript critically, and final approval of the version to be published; **Michael A. Carron**, analysis and interpretation of data, revising the manuscript critically, and final approval of the version to be published; **Giancarlo F. Zuliani**, acquisition and analysis of data, revising the manuscript critically, and final approval of the version to be published; **Wei Chen**, statistical analysis of data, revising the manuscript critically, and final approval of the version to be published; **George H. Yoo**, analysis and interpretation of data, revising the manuscript critically, and final approval of the version to be published; **Robert H. Mathog**, critical interpretation of data, revising the manuscript critically, and final approval of the version to be published.

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Supplemental Material

Additional supporting information may be found at <http://oto.sagepub.com/content/by/supplemental-data>

blood loss was 12.5 mL (range, 5–75 mL). Complications occurred in 4 cases (22%) to include temporary vocal cord pareses (n = 3) and a postoperative hematoma that required exploration. Median hospital stay was 2 days (range, 1–3 days).

Conclusion—Single-incision transaxillary robotic thyroidectomy can be technically challenging in North American patients with a larger body frame due to difficulty in optimal placement of all 4 robotic instruments via a single axillary incision. All 3 cases of temporary vocal cord paresis occurred early in our experience and may have been due to our relative inexperience with this new approach and associated instrumentation. Other limitations include less than optimal visualization of the recurrent laryngeal nerve in the contralateral lobe as well as poor access to the substernal region.

Level of Evidence—4

Keywords

thyroid surgery; robotic thyroidectomy; transaxillary; thyroid

Since its original description by Theodor Kocher,¹ the surgical approach for resection of the thyroid has remained essentially the same for more than a century. With the advent of new technology and the desire of surgeons to reduce surgical morbidity and improve cosmesis, minimally invasive and remote-access thyroid surgeries were finally introduced in the past decade. In 1996, Gagner² was the first to apply an endoscopic technique to endocrine surgery when he reported the first case of endoscopic subtotal parathyroidectomy. Miccoli et al^{3–5} introduced the minimally invasive video-assisted thyroidectomy (MIVAT) in 2000. At around the same time, the pursuit for “no scar” in neck surgery led to the introduction of various extra-cervical approaches. These extra-cervical endoscopic approaches take advantage of areas outside the neck region that can be camouflaged such as the areola in the breast approach,⁶ the armpit in the axillary approach,⁷ and both in the combined approach.^{8,9} Having had extensive experience in the endoscopic transaxillary approach,¹⁰ Kang et al¹¹ were the first to describe transaxillary robotic thyroidectomy. With the use of the da Vinci Robot (Intuitive Surgical, Inc, Sunnyvale, California), they were able to overcome many of the limitations associated with the conventional endoscopic approach such as inadequate visualizations and inability to execute precise manipulation of the endoscopic instruments for meticulous dissection.¹¹

In the original description by the South Korean group, robotic thyroidectomy was performed via 2 incisions (axillary and anterior chest wall).¹¹ In an effort to further reduce the invasive nature of this surgery, a modification of the original technique to comprise only 1 axillary incision was described.^{12,13} Since then, only 2 groups^{14,15} have reported on the feasibility of using this single-incision transaxillary robotic approach in North American patients whose body builds and thyroid pathology differ significantly from patients described by Kang et al.¹¹ Given the relatively limited experience of this new technique, we aim to review our initial experience to identify challenges and limitations of single-incision transaxillary robotic thyroidectomy when applied to a North American population.

Methods

A retrospective analysis of our initial surgical experience with single-incision robot-assisted thyroidectomy was performed after receiving approval from the Wayne State University Institutional Review Board. A single surgeon (H.-S.L.) performed all of the cases. Patient demographics were recorded to include age, race, sex, height, weight, and body mass index (BMI). Other data recorded included indications for surgery, preoperative diagnosis, size of thyroid gland and nodules based on both preoperative imaging and final pathology, weight

of thyroid gland on final pathology, size of incision, laterality of the surgery, number of incisions, operative time, blood loss, number of robotic instruments used, final pathologic diagnosis, duration of hospital stay, intraoperative complications, postoperative complications, and outcomes. Owing to the descriptive nature of this study, data were summarized using descriptive statistics such as mean or median and range.

Patient Selection

Although arbitrarily defined eligibility criteria for robot-assisted thyroid surgery have been described by some authors,¹⁵ standard and well-accepted selection criteria have not been established.¹⁶ In this study, all patients who were candidates for open thyroid lobectomy were offered the option of the robotic approach. In the majority of cases, this included patients who required thyroid lobectomy either for diagnostic purposes because of fine-needle aspiration (FNA) suggestive of follicular lesion/neoplasm or for symptomatic reasons because of large goiter. Given the lack of well-accepted selection criteria in the literature, we did not use an absolute cutoff value in terms of size of thyroid lobe, size of thyroid nodule, or BMI as eligibility criteria. The only 2 absolute contraindications to the robot-assisted thyroidectomy in this study were substernal extension and any thyroid pathology requiring total thyroidectomy. Patients with substernal goiter were excluded since visualization and access to the area below the clavicle are difficult with the transaxillary approach. Furthermore, patients with thyroid pathology who required a single-stage total thyroidectomy were excluded because of the difficulty of adequately visualizing the contralateral recurrent laryngeal nerve (RLN) to perform a complete total thyroidectomy safely.

Surgical Technique

The operative techniques have been previously described in detail by both the Korean^{12,13} and American groups.^{14,15} Here, we will briefly describe our slightly modified version.

Skin incision was marked in the preoperative holding area with the patient sitting and with arms relaxed in a natural position to ensure adequate concealment of the incision. A Nerve Integrity Monitor (NIM) endotracheal tube (Medtronic, Minneapolis, Minnesota) was used for intubation, and the NIM nerve monitor (Medtronic) was set up. Initially, we extended the arm ipsilateral to the target thyroid lobe straight superiorly as described by the Korean group. After initial reports of neuropraxias associated with this position by several surgeons (personal communication), we modified the positioning so that the extended arm was flexed approximately 90° at the elbow with the forearm resting over the forehead. Care was taken to place the arm in a natural relaxed position and to provide adequate padding and fixation. Following axillary incision, a working space was created in the plane between the subcutaneous tissue and the pectoralis major muscle up to the clavicle. The space between clavicular and sternal heads of the sternocleidomastoid muscle was then identified, and dissection was carried deep to the sternal head to expose and dissect the strap muscles off the thyroid lobe. A Kuppersmith retractor (Marina Medical, Sunrise, Florida) was placed under the muscles to maintain the working space.

After docking the robot, three 8-mm instruments (ProGrasp forceps, harmonic shears, and Maryland dissector; Intuitive Surgical) as well as the 30° endoscope (Intuitive Surgical) were introduced through the single axillary incision. Proper placement of the 4 robotic arms and instruments was critical to avoid collision and interference. The 30° endoscope was introduced from the lowest part of the incision and angled upward. The ProGrasp forceps was then positioned in the ceiling of the working space as close as possible and parallel to the retractor blade. The setup for a left thyroidectomy is shown in Figure 1. Thyroidectomy was then performed in a standard fashion. With downward traction of the gland, superior

thyroid vessels were identified and transected using harmonic shears closed to the gland. The thyroid lobe was then retracted medially, and the RLN and inferior parathyroid gland were identified. Following ligation of the inferior thyroid vessels, the thyroid lobe was then meticulously dissected freed from Berry's ligament and transected (Video 1, available at www.otojournal.org).

Results

From February 2010 to April 2012, 16 patients underwent 18 robot-assisted thyroid surgeries. All 16 patients (100%) were women, with 6 (38%) whites, 2 (12%) Middle Eastern Americans, and 8 (50%) African Americans. The median age was 47.5 years (range, 18–62 years), and the median BMI was 28.7 (range, 19.4–44.5). Two patients each underwent 2 separate robot-assisted thyroidectomies (one for cancer and the other for bilateral goiter), resulting in a total of 18 separate robot-assisted thyroid lobectomies that comprised this study (Table 1).

Indications for surgery included 9 (50%) enlarging symptomatic nodules with nondiagnostic or benign pathology on FNA, 8 (44%) follicular lesions on FNA, and 1 (6%) follicular variant of papillary thyroid cancer on the previously removed thyroid lobe. Ten (56%) left and 8 (44%) right thyroid lobectomies were performed. The median size of the thyroid lobes, as measured by the largest dimension on pre-operative imaging, was 5.4 cm (range, 3.4–9.4 cm). The median size of the largest dimension of the thyroid nodule was 2.9 cm (range, 1.1–4.7 cm). Median weight of the thyroidectomy specimen on the pathology report was 13.9 g (range, 4.3–34.0 g). Final pathology showed 10 (55%) benign nodule/hyperplasia, 3 (17%) Hashimoto's thyroiditis, and 5 (28%) follicular variant of papillary thyroid cancer (Table 2).

Despite various attempts to position and angle both the robotic arms/instruments and the patient, the insertion of all 4 instruments via a single axillary incision remained challenging in 5 cases. In 4 such cases, only 3 instruments were placed through this single incision, and the surgery was accomplished using the scope and 2 robotic instruments (harmonic shears and Maryland dissector) without the ProGrasp forceps. In 1 patient, a separate 1-cm incision was made over the anterior chest to accommodate the ProGrasp forceps. Thus, all but 1 case (6%) was performed successfully via the single axillary incision. There was no conversion to the open approach. The median length of incision was 7 cm (range, 6–9 cm).

Median total operative time was 170 minutes (range, 95–220 minutes) with a median console time of 60 minutes (range, 30–80 minutes). Median preoperative setup time for patient intubation and patient positioning was 40 minutes (range, 25–70 minutes). Median blood loss was 12.5 mL (range, 5–75 mL). One (6%) postoperative hematoma required exploration in the operating room to ligate an anterior chest wall vessel. Three (17%) temporary vocal cord pareses were identified postoperatively, and all of them resolved within 2 to 4 months following the surgery. No esophageal or tracheal injury or neuropraxia was encountered. Median hospital stay was 2 days (range, 1–3 days). The delay in discharge was mainly due to high-volume drain output in many of our patients who had a large amount of dissected subcutaneous tissue (Table 3). Although not formally quantitated, all patients were happy with the well-hidden axillary incision.

Discussion

In the original description by the South Korean group, robot-assisted thyroidectomy was performed via 2 incisions (axillary and anterior chest wall).¹¹ In an effort to further reduce the invasive nature of this surgery, a modification of the original technique to comprise only

1 axillary incision was described.^{12,13} Because of the significant difference in body habitus and thyroid pathology between the Korean and North American patients, there was initially some doubt with regard to the applicability of this single-incision technique in North American patients.¹²

Since then, 2 groups^{14,15} have reported on the feasibility of using this single-incision transaxillary robotic approach in North American patients. Kuppersmith and Holsinger¹⁴ reported on their initial experience with 31 cases of robotic thyroid surgery. For the first 15 cases, both axillary and chest wall incisions were used, whereas the remaining 16 cases were performed through a single transaxillary incision. Although the authors did not specifically mention any exclusion criteria, the mean BMI in their group was 24.7 (range, 18.2–34.2), and mean size of the thyroid mass was 2.7 cm (range, 1–4.6 cm). Landry et al¹⁵ reported on 12 cases of robot-assisted transaxillary surgery for removal of thyroid glands. In their series, they excluded patients with thyroid lobe size >6.5 cm and BMI >35. Their median BMI was 25.3 (range, 21.3–34.4), and median size of the thyroid was 4.7 cm (range, 2.3–6.3 cm). Since we did not place any restriction in terms of thyroid size or BMI, our series included patients with a higher median BMI of 28.7 (range, 19.4–44.5), larger median thyroid nodule of 2.9 cm (range, 1.1–4.7 cm), and larger median thyroid size of 5.4 cm (range, 3.4–9.4 cm).

Although technically feasible, single-incision robotic thyroidectomy may be technically challenging in some patients. Correct positioning of the robotic arms and the patient is key to successful completion of this procedure. Precise spacing and exact angling of instruments are critical to prevent instrument collisions that may limit the mobility required for delicate and safe tissue dissection. Based on our own experience, the positioning of the robotic arm holding the ProGrasp forceps is perhaps the most challenging, especially in larger built patients. To properly position the ProGrasp forceps in the ceiling of the working space in a direction parallel and caudal to the retractor blade, the bulky hinge of the robotic arm (#2 in left thyroidectomy and #1 in right thyroidectomy) often ends up right over the top of the patient's chest and abdomen (Figure 1). Several simple maneuvers, such as putting the patient in reverse Trendelenburg, tilting the operating table, and changing the angle and distance of the docked robot to the operating table, can be tried to optimize positioning. If a safe distance between the hinge of the robotic arm and the patient's body cannot be created despite the use of these maneuvers, consideration should be given to conversion to the originally described 2-incision technique in which the ProGrasp forceps is introduced via a separate chest incision. Alternatively, we have found it feasible to move the ProGrasp forceps out of the operative field and perform the entire surgery using only the Maryland dissector and harmonic scalpel. It is likely that future miniaturization of robot and instrumentation will make this technical challenge irrelevant.

Other limitations of this single-incision transaxillary approach include less than optimal visualization of the RLN in the contralateral lobe as well as poor access to the sub-sternal region. The difficulty with visualizing the contralateral RLN to safely complete a total thyroidectomy may be overcome with improved clinical experience, as demonstrated by the Korean group who performed a large number of total thyroidectomies.^{11,13,17,18} Other recently described robotic-assisted thyroidectomy approaches such as the trans-oral¹⁹ and the facelift²⁰ approaches may also overcome these limitations by approaching the thyroid from above.

Studies from the Korean group indicate that complication rates are the same or lower, but this is primarily based on the experience of 1 group of very experienced endoscopic thyroid surgeons.^{11,17,21} Furthermore, this procedure does have the potential to cause complications not normally seen in open thyroid surgery. Landry et al¹⁵ reported complications in 4 of their 14 cases (28.5%) to include temporary ulnar nerve paresthesia (n = 1), shoulder pain

with decreased range of motion (n = 1), postoperative hematoma (n = 1), and wound infection (n = 1). Koppersmith et al¹⁴ reported complications including distal radial nerve neuropraxia (n = 1), transient vocal cord paresis (n = 1), significant blood loss due to transection of the anterior jugular vein (n = 2), and inability to complete total thyroidectomy as originally planned (n = 2). Other potential complications include conversion to an open procedure and injury to the carotid artery, jugular vein, vagus nerve, trachea, and esophagus. In our series of 18 cases, we encountered 1 postoperative hematoma that required exploration in the operating room to ligate an anterior chest wall vessel. One surprising finding in this study was the high rate of temporary vocal cord paresis (n = 3) that occurred early in our series (cases 4, 6, and 9). Although speculative at best, the reason for this high rate of temporary nerve injury may include poor visualization and exposure of the nerve as well as our relative inexperience with this new approach and associated instrumentation, such as the harmonic scalpel. Most surgeons are accustomed to using a cold clamp in soft tissue dissection during an open approach. Even in a minimally invasive approach such as MIVAT, the use of the harmonic scalpel is typically limited to the ligation of vasculatures. Thus, the use of the harmonic scalpel in a more dominant fashion during soft tissue dissection in robotic thyroidectomy can be a new experience for many surgeons. This inexperience and the failure to allow the shears to cool down after activation before further soft tissue dissection may have contributed to inadvertent thermal injury to RLN early in our experience. Ever since, we have become more mindful about this potential danger, and we have not observed any further instances of temporary nerve paresis. Several authors have also reported on a higher than expected rate of RLN injury (13.3%²² and 14.3%²³) during endoscopic or robotic thyroidectomy when the harmonic scalpel was used and attribute this increased incidence to possible thermal injury.^{22–24} We therefore recommend that, during the training process, surgeons should practice using the harmonic scalpel in routine open thyroidectomy cases to gain experience with the use of the harmonic scalpel for soft tissue dissection.

Given the retrospective nature of this study as well as the small sample size, many important questions such as cost-benefit analysis and appropriate patient selection cannot be adequately addressed. At this point, the individual surgeon needs to take into account his or her own experience and comfort level as well as various patient and disease factors when deciding whether a patient is a suitable candidate for this procedure. In general, novice surgeons should select their patients very carefully and exclude patients with Graves disease, Hashimoto's thyroiditis, obesity, definitive diagnosis of thyroid cancer, history of irradiation or surgery to the neck, and large thyroid goiter. Clearly, a thin female patient with a small unilateral nodule found to be a follicular neoplasm or a lesion on FNA and who desires the avoidance of a neck incision would be an ideal patient for this procedure. Darker skin patients such as Asian Americans and African Americans who have an increased tendency to form unsightly hypertrophic scars as well as teenagers who are more conscious of their physical appearance may benefit from this robotic surgery. Surgeons also must consider how they will proceed if a patient's permanent pathology turns out to be malignant. This occurred in 4 of our patients. Fortunately, 2 of these patients have low-risk disease with tumor size less than 1 cm without any extra-thyroidal extension. For the other 2 patients who required completion thyroidectomy, 1 patient opted for a standard conventional cervical approach for completion thyroidectomy, whereas the other opted for robot-assisted thyroidectomy via a new incision on the contralateral axilla. With increasing experience and continuing improvement in the robotic technology, the indications for robotic thyroid surgery will likely continue to evolve. However, as surgeons continue to push the envelope to expand the application of this new technology, extreme care must be exercised to ensure patient safety.

In this review, we showed that a single-incision robot-assisted thyroidectomy is technically feasible but challenging for a diverse group of North American patients in this study. This

procedure does have the potential to cause complications not normally seen in open thyroid surgery. The surprisingly high rate of temporary vocal cord paresis seen early in this series may be due to our relative inexperience in this new approach, including unfamiliarity with the use of harmonic shears in soft tissue dissection. Robotic surgeons need to be mindful that the dissecting tip of the harmonic shears can remain quite hot after activation. Since the use of this procedure is in its early infancy in North America, there remain many unanswered questions. Currently, there are no standardized criteria to identify patients who would most benefit from this procedure. More studies need to be performed to further evaluate the benefits and limitations of this new technique.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Positioning of the robotic instruments for a single-incision robot-assisted left thyroid lobectomy.

Table 1

Patient Demographics (n = 16)

Clinical Characteristics	No. (%)	Median (Range)
Sex		
Female	16 (100)	
Male	0	
Race		
White	6 (38)	
Middle Eastern American	2 (12)	
African American	8 (50)	
Age, y		47.5 (18.0–62.0)
Body mass index		28.7 (19.4–44.5)

Table 2

Clinicopathologic Characteristics of Thyroid Lobes/Nodules (n = 18)

	No. (%)	Median (Range)
Laterality		
Left	10 (56)	
Right	8 (44)	
Largest dimension of thyroid lobe, cm Imaging		5.4 (3.4–9.4)
Largest dimension of nodule, cm Imaging		2.9 (1.1–4.7)
Largest dimension of thyroid lobe, cm Pathology		4.7 (1.5–8.5)
Weight of thyroid lobe, g Pathology		13.9 (4.3–34.0)
Largest dimension of nodule, cm Pathology		2.4 (1.0–3.5)
Preoperative pathology		
Nondiagnostic or no biopsy	4 (22)	
Benign colloid nodule	5 (28)	
Follicular lesion	8 (44)	
Follicular variant of papillary thyroid cancer	1 (6)	
Postoperative pathology		
Nodule/hyperplasia	10 (55)	
Hashimoto	3 (17)	
Follicular variant of papillary thyroid cancer	5 (28)	

Table 3

Clinical Characteristics of Robot-Assisted Thyroidectomies (n = 18)

	No. (%)	Median (Range)
Incision size, cm		7 (6–9)
Number of incisions		
1	17 (94)	
2	1 (6)	
Conversion to open		
No	18 (100)	
Yes	0	
Blood loss, mL		12.5 (5–75)
Total operative time, min		170 (95–220)
Incision and flap elevation		75 (30–120)
Robot setup		22.5 (15–35)
Robotic thyroidectomy		60 (30–80)
Number of instruments used		
2	4 (22)	
3	14 (78)	
Hospital stay, d		2 (1–3)
Complications		
Nerve paresis	3 (17)	
Hematoma	1 (6)	