# Prospects of Robotic Thyroidectomy Using a Gasless, Transaxillary Approach for the Management of Thyroid Carcinoma

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**Purpose:** Robotic surgical systems are among the most innovative surgical developments and have radically promoted the use of minimally invasive techniques. Robotic technologies using different approaches have also been applied to thyroid surgery. Recently, the authors described a novel robotic surgical method for thyroid surgery based on a gasless, transaxillary approach (TAA), and have since serially reported on its technical feasibility and safety. Here, the authors report their experience of a consecutive series of 1000 cases treated using robotic thyroidectomy, and demonstrate its use for the surgical management of thyroid cancer.

**Patients and Methods:** From October 2007 to November 2009, 1000 patients with thyroid cancer underwent robot-assisted endoscopic thyroid surgery using a gasless TAA. All patients were selected using predetermined inclusion criteria after considering surgical risk, and all procedures were completed successfully using the da Vinci S or Si surgical system (Intuitive Surgical, Sunnyvale, CA). Patient's clinicopathologic characteristics, operation types, operation times, numbers of retrieved lymph nodes (LNs), postoperative hospital stays, complications, and short-term follow-up results were analyzed.

**Results:** Mean patient age was $39.1 \pm 9.6$ years and the male-to-female ratio was 1:12.6 (73:927). Six hundred twenty-seven patients underwent less than total and 373 patients underwent bilateral total thyroidectomy. Ipsilateral central compartment node dissection was conducted in all 1000 cases and additional lateral neck node dissection was conducted in 36 of the 1000 patients. Mean operation time was $136.7 \pm 44.4$ minutes and mean postoperative hospital stay was $3.0 \pm 0.45$ days. No serious postoperative complication occurred, except 3 cases of recurrent laryngeal nerve injury, and 1 case of Horner syndrome. Mean tumor size was $0.79 \pm 0.6$ cm and papillary thyroid microcarcinoma was in 752 cases (75.5%). The mean number of retrieved central LNs per patient was $4.62 \pm 3.14$. Central neck LN metastasis occurred in 361(36.1%) and lateral neck LN metastasis in 36 cases (3.6%). According to tumor nodes metastasis staging, 847 patients (84.7%) were of stage I, 144 patients (14.4%) were of stage III, and 9 patients (0.9%) were of stage IVA.

**Conclusions:** The authors conclude that robotic thyroidectomy using a gasless TAA is a feasible, safe, and promising surgical alternative for selected patients with low-risk thyroid cancer, and recommend that the inclusion criteria of this technique be gradually extended to advanced thyroid cancer given suitable operator experience and future developments in robotic systems and instrumentation.

**Key Words:** robotic procedure, thyroid cancer, gasless, transaxillary approach

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Tailored anticancer therapy has gained worldwide acceptance for medical and surgical treatments based on considerations of primary tumor biology. In the head and neck area, well-differentiated thyroid carcinomas are more prevalent in young women, and usually show favorable biological behavior and better prognosis than other head and neck cancers.[1–3] Furthermore, the evolution of minimally invasive techniques for thyroid cancer treatment has been driven by the pursuit of cosmetic results.

Since the late 20th century, various types of minimally invasive techniques have been introduced for thyroid surgery, but several instrumental and anatomic limitations have restricted the general adoption of these techniques.[4,5] However, the recent incorporations of surgical robotic systems into thyroid surgery have largely overcome these limitations and have increased the precisions of endoscopic techniques.[6–8]

Recently, we published a serial report on robotic thyroid surgery for papillary thyroid carcinoma using a gasless, transaxillary approach (TAA), which demonstrated its technical feasibility and safety.[8–11] During our experiences, we gradually extended the inclusion criteria, examined new instruments, and modified surgical techniques.[11,12] In this study, we describe our experiences and the lessons learned from consecutive 1000 cases of robotic thyroidectomy, and we demonstrate its use for the surgical management of thyroid cancer.

## PATIENTS AND METHODS

### Patients

From October 2007 to November 2009, 1019 patients underwent robotic thyroidectomy using a gasless, TAA approach, as previously described.[8–11] Nineteen patients with benign thyroid disease were excluded, and the remaining 998 patients with a preoperative diagnosis of well-differentiated thyroid carcinoma and 2 patients with medullary thyroid carcinoma were enrolled in this study. Of these, 36 patients underwent additional robotic modified radical neck dissection (MRND) for lateral neck lymph

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node (LN) metastasis.[12] The enrolled patients were divided into 4 groups according to operation dates; first period group (October 2007 to March 2008, N = 108), second period group (April 2008 to September 2008, N = 163), third period group (October 2008 to March 2009), and fourth period group (April 2009 to November 2009). All operations were performed using the da Vinci S or Si surgical robotic system (Intuitive Surgical, Sunnyvale, CA).

Details of clinical characteristics, operation times, postoperative hospital stays, complications, and pathologic characteristics were obtained from a prospectively maintained institutional database.

The eligibility criteria applied were: (1) well-differentiated thyroid carcinoma; (2) a tumor size of ≤4 cm; and (3) minimal invasion to the anterior thyroid capsule and strap muscle; and the exclusion criteria applied were: (1) definite tumor invasion to an adjacent organ [recurrent laryngeal nerve (RLN), esophagus, or trachea]; (2) multiple lateral neck node metastases or perinodal infiltration at a metastatic LN. The extent of thyroid resection (total or less than total thyroidectomy) was determined using the guidelines issued by the American Thyroid Association.[13]

## Operative Methods

We have previously described the procedures used for robotic thyroidectomy and MRND.[9,11,12]

### Double-incision Robotic Thyroidectomy

With the patient in the supine position under general anesthesia, the neck is slightly extended, and the lesion-side arm is raised and fixed for the shortest distance from the axilla to the anterior neck (Fig. 1).

A 5 to 6-cm vertical skin incision is then made along the lateral border of the pectoralis major muscle in the axilla. A subplatysmal skin flap from the axilla to the anterior neck area is then dissected over the anterior surface of the pectoralis major muscle and clavicle by electrical cautery under direct vision. After exposing the medial border of the sternocleidomastoid (SCM) muscle, the dissection is approached through the avascular space between the sternal and the clavicular heads of the SCM muscle and beneath the strap muscle until the contralateral lobe of the thyroid is exposed. An external retractor is then inserted through the skin incision in the axilla and raised to maintain a working field. A second skin incision (0.8 cm in length) is made on the medial side of the anterior chest wall, 2 cm superior and 6 to 8 cm medial to the nipple, to insert the fourth robot arm. Dual channel camera (Intuitive Inc.), Harmonic curved shears (Intuitive Inc.), and Maryland dissector (Intuitive Inc.) are inserted through an axillary incision. The Harmonic curved shears, which is used for all dissections and ligations of vessels, and the Maryland dissector are placed on both lateral sides of the camera, and a Prograsp forceps (Intuitive Inc.) is placed on the anterior chest arm (Fig. 2). After the upper pole of the thyroid is drawn downward and medially using the Prograsp forceps, the superior thyroid vessels are identified and divided. After retracting the thyroid gland medially with the Prograsp forceps, careful dissection is continued to identify the inferior thyroid artery and the RLN in their usual anatomic relationship. After tracing the entire running course of the RLN and identifying the superior parathyroid gland, the thyroid gland is dissected from the trachea. Contralateral thyroidectomy is performed using the same method used for medial traction of the thyroid.

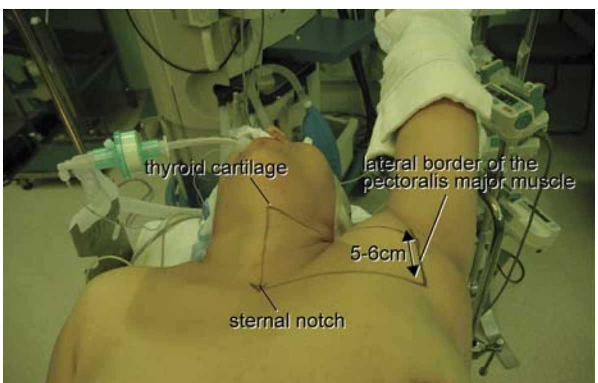


**FIGURE 1.** Patient's position for the robotic thyroidectomy.

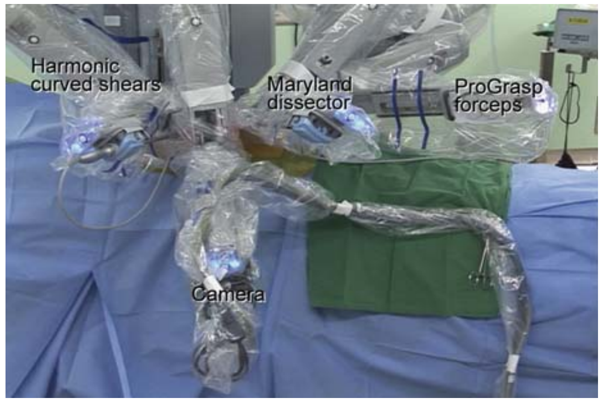


**FIGURE 2.** Double-incision robotic thyroidectomy; external view of robotic arms.

### Single-incision Robotic Thyroidectomy

Patient positioning and working space creation are same as those of double-incision robotic thyroidectomy, but the anterior chest incision differs. After creating a working space, the robot arms are docked. Unlike the previously described double-incision method, during this method, the robotic arms are inserted through a single incision in the axilla. To prevent interference between robotic arms, the placement of the ProGrasp forceps and the angle and interarm distances of the robotic arms are extremely important. The actual locations of the robotic arms are the same as for the double incision method, but the ProGrasp forceps location differs. For the Right side approach, a 12 mm trocar with a 30-degree down view dual channel endoscope is located in the center of the axillary incision. The camera should be placed in the lowest part of the incision with its tip directed upward. An 8 mm trocar for the ProGrasp forceps is then positioned on the right of the camera parallel with the suction tube of the retractor blade. At this time, the ProGrasp forceps must be located as close as possible to the retractor blade. The 5 mm trocar of a Maryland dissector is then positioned on the left of the camera, and the 5 mm trocar for the Harmonic curved shears on the right side of the camera. The Maryland dissector and Harmonic curved shears should be as far apart as possible (Fig. 3). The procedure used is same as that of double incision robotic thyroidectomy, except for

 

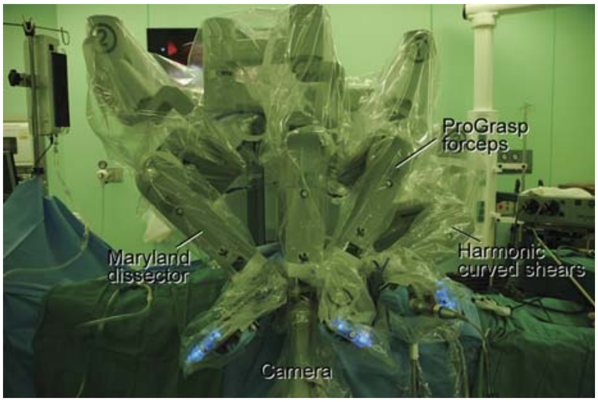


**FIGURE 3.** Single-incision robotic thyroidectomy; external view of robotic arms.

the use of the ProGrasp forceps. Initially, we used movements of the endowrist and of the external joint of the Prograsp forceps to achieve tissue traction. However, during the single-incision approach, tissue should be drawn using only endowrist motion of the forceps and its external joint should be articulated as little as possible. As all 4 robotic arms are inserted through the same incision, it is best to avoid large movements of external joints of the robotic arms to prevent collisions.

## Total Thyroidectomy With Central Compartment Node Dissection and MRND

Under general anesthesia, the patient is placed in the supine position on the surgical table with a soft pillow under shoulder. The lesion side arm is abducted to expose the axilla and the lateral neck, and the patient's head is tilted and rotated to face the opposite side (Fig. 4).

The landmarks for dissection are demarcated by the sternal notch and the midline of the anterior neck medially, the anterior border of trapezius muscle laterally, and the submandibular gland superiorly. In brief, a 7 to 8-cm vertical skin incision is placed in the axilla along the anterior axillary fold and the lateral border of the pectoralis major muscle, and a subcutaneous skin flap is made over the anterior surface of the pectoralis muscle from axilla to the clavicle and the sternal notch. After crossing the clavicle, a subplatysmal skin flap is made. The flap is dissected medially over the SCM muscle toward the midline of the anterior neck. Laterally, the trapezius muscle is identified and dissected upward along its anterior border. The spinal accessory nerve is preserved by careful skeletonization of the trapezius muscle and is traced along its course until it passes on the undersurface of the SCM muscle. The subplatysmal skin flap is elevated upward over the anterior surface of the SCM muscle until the submandibular gland superiorly and the upper third of the SCM muscle is exposed laterally. The clavicular head of the SCM muscle is divided at the level of its attachment to the clavicle to expose the jugular chain. The dissection of the SCM muscle fascia begins at the posterior edge of the muscle and proceeds in a medial direction beneath the 2 heads of the SCM muscle. The external jugular vein is ligated at the crossing point of the SCM muscle and the dissection proceeds upward until the submandibular gland and the posterior belly of digastric muscle are exposed. The superior belly of omohyoid muscle is divided at the level of thyroid cartilage, and the thyroid gland is detached from the strap muscles. A long and wide retractor blade designed for the MRND is then inserted through the axillary incision and placed between the thyroid and the strap muscle. The entire thyroid gland and the level IIa, III, IV, Vb, and VI areas are fully exposed by elevating the 2 heads of the SCM muscle and the strap muscles. A second skin incision for the fourth robotic arm is made on the anterior chest wall, 6 to 8 cm medially and 2 to 4 cm superiorly from the nipple. The docking procedure used is similar to that used for robotic thyroidectomy described above (double incision method). The camera is inserted at the center of the incision, the Maryland dissector is installed on the left side of the camera, and the Harmonic curved shears is installed on the right side of the camera. A ProGrasp forceps is installed on the anterior chest wall.

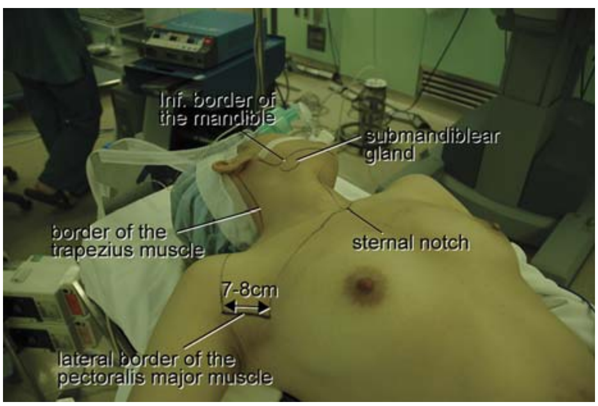


**FIGURE 4.** Patient's position for the robotic modified radical neck dissection.

Total thyroidectomy with central compartment node dissection is performed in the same manner as double-incision thyroidectomy.

Lateral neck node dissection is started at the level III/IV area around the IJV. Careful dissection is needed during the detachment of the LN from the posterior aspect of IJV to avoid injury to the common carotid artery and the vagus nerve. The skeletonization of the IJV proceeds to the upper part of level III area. After mobilizing the upper part of level III/IV area, the dissection is continued to the lower level IV area. Careful dissection is performed to avoid injury to the thoracic duct. After clearing the level IV area, the inferior belly of the omohyoid muscle is divided and the LN in supraclavicular area is detached. The dissection follows the surface of the deep layer of the deep cervical fascia while avoiding injury to the phrenic nerve. The transverse cervical vessels are identified and preserved, and the external jugular vein is ligated with a Hemolock clip at the inlet to the subclavian vein. The dissection then proceeds upward along the anterior border of trapezius muscle while preserving the spinal accessory nerve. After finishing level III, IV, and Vb node dissections, redocking is needed to obtain a better view for level II LN dissection. The external retractor is removed and reinserted through the axillary incision toward the submandibular gland. The second docking procedure is done in the same manner as the first docking procedure. Then, level IIa dissection proceeds to the posterior belly of digastric muscle and the submandibular gland superiorly. The specimen is then delivered and a 3-mm closed suction drain is inserted, as described above for robotic thyroidectomy. The wound is then closed cosmetically.

## RESULTS

In this study, 1000 consecutive cases were reviewed. Mean patient age was 39.1 ± 9.6 years, and the cohort was consisted of 927 female and 73 male patients. Six hundred twenty-seven patients underwent less than total and 373 patients underwent bilateral total thyroidectomy. Ipsilateral central compartment node dissection was conducted in all cases and additional lateral neck node dissection in 36 patients. No case was converted to conventional open surgery. Mean total operation time was 136.7 ± 44.4 minutes, and mean postoperative hospital stay was 3.0 ± 0.45 days. (Table 1)

Mean tumor diameter was 0.79 ± 0.6 cm and 752 patients (75.5%) had papillary thyroid microcarcinoma (tumor size ≤1 cm). Multiple or bilateral thyroid gland lesions were observed in 231 (23.1%) and 106 cases (10.6%), respectively. The mean number of LNs retrieved per patient was 4.62 ± 3.14 from the central compartment and 27.7 ± 11.0 from the lateral neck compartment.

According to the tumor nodes metastasis stage classification, 512 patients (51.2%) had T1, 9 patients (0.9%) had T2, 473 patients (47.3%) had T3, and 6 patients (0.6%) had T4a stage tumors. In T3 stage patients, most tumors were < 2 cm, but nevertheless invaded the thyroid capsule. In the T4a patients, 5 patients showed RLN invasion and 1 showed tracheal invasion. Four of 5 patients with RLN invasion underwent a successive shaving procedure using robotic or endoscopic scissors, but in one, the RLN should be sacrificed due to complete tumor invasion of the nerve core. One patient with tracheal invasion was also managed using a shaving procedure because the invasion only reached tracheal perichondrium. In terms of N stage, 639 patients (63.9%) had N0, 325 patients (32.5%) had N1a, and 36 patients (3.6%) had N1b. No patient had distant metastasis. Accordingly, 847 patients (84.7%) had stage I disease, 144 patients (14.4%) had stage III, and 9 patients (0.9%) had stage IVA tumor (Table 2). The trends of robotic thyroidectomy with experience showed several changes in clinical performance statuses. Specifically, total thyroidectomy and MRND cases increased and total operation times decreased (Table 3).

In terms of postoperative complications, 145 patients had transient hypocalcemia, but this resolved within 3 months in all patients. Permanent hypocalcemia was not encountered in any patient, and only 1 patient required reoperation due to postoperative bleeding (tearing of the external jugular vein). The 42 cases of transient hoarseness resolved within 2 to 3 months of laryngoscopy. Three cases of a minor chyle leak occurred and all responded to conservative management within a few days. There were 3 cases of permanent RLN injury, 2 cases of tracheal wall injury, and 2 cases of transient brachial nerve paralyses due to overstretching of the lesion side arm (Table 4). All RLN injury patients underwent injection laryngoplasty using Rofilan. Two patients with transient brachial nerve paralysis spontaneously recovered within 2 months. Two tracheal wall injury patients were managed by primary tracheal repair using robotic instruments.

**TABLE 1.** Clinical Characteristics of the Patients

| | N = 1000 |
|---|---|
| Age (y) | 39.1 ± 9.6 (range, 15-70) |
| Sex ratio (male:female) | 73:927 (ratio 1:12.6) |
| Operation type (N) | |
| Total thyroidectomy with CCND (+ MRND) | 373 (36) |
| Less than total thyroidectomy with CCND | 627 |
| Operation time (min) | 136.7 ± 44.4 (69-347 min.) |
| Postoperative hospital stay (d) | 3.0 ± 0.45 (2-7) |

CCND indicates central compartment neck dissection; MRND, modified radical neck dissection.

Of the 373 patients that underwent bilateral total thyroidectomy, 209 underwent radioactive iodine (RAI) therapy (with 30 mCi for only total thyroidectomy cases and 150 mCi for additional MRND cases) at 1 to 3 months postoperatively, and $^{131}$I whole body scan 2 days after RAI therapy. No patient was found to have abnormal RAI uptake. At 4 months postoperatively, serum thyroglobulin levels (thyroid-stimulating hormone suppressed) were checked. Serum thyroglobulin levels in 142 patients (67.9%) were < 1 ng/mL and in the remaining 67 patients (32.1%) were > 1 ng/mL (4.06 ± 2.31 ng/mL). All patients underwent neck ultrasonography at 12 and 24 months postoperatively to check for local recurrence, but no recurrence was found (Table 5).

## DISCUSSION

Endoscopic thyroidectomy was initially considered fashionable modality in north-east Asia.[5,14–17] Owing to the definite limitations of endoscopic procedures of the thyroid gland, such as, instrumental, spatial (no preexisting working space and a small and narrow operation field), and anatomic limits (the proximities of important motor nerves and major vessels to target organs), the endoscopic approach did not gain worldwide acceptance for thyroid surgery in the inception.[6–8] However, during the early 21st century, the incorporation of cutting-edge robotic technology provided a safe and feasible approach for endoscopic thyroidectomy.[6–8] The trailblazers of minimally invasive head and neck surgery introduced robot-assisted endoscopic thyroidectomy, and serially demonstrated the surgical safety and feasibility of robotic techniques for thyroid surgery.[6–11] Subsequently, many thyroid surgeons have adopted robotic thyroidectomy, and several teams have reported their successful experiences of this new approach.[18–24]

Before the first application of robotics to thyroid surgery in 2007, the authors had performed more than 650 endoscopic thyroidectomies using gasless TAA from 2001. We started robotic thyroid surgery based on the feasibility and the safety of endoscopic thyroidectomy in papillary thyroid microcarcinoma,[5,16] but we limited initial cases to well-differentiated thyroid carcinoma with a tumor size of ≤2 cm without definite extrathyroidal tumor invasion (T1 lesions) or to follicular neoplasms with a tumor size of ≤5 cm.[8,9] After demonstrating the surgical safety, feasibility, and functional benefits of robotic thyroidectomy, we conducted comparative studies versus conventional methods, and multicenter trial studies to determine its technical reproducibility.[25–29] As robotic experience accumulated, we were able to successfully manage unexpectedly encountered advanced cases, such as, cases with definite adjacent muscle invasion or multiple nodal metastases without open

**TABLE 2.** Pathologic Characteristics of the Patients

| **Variables** | **N = 1000** | |
|---|---|---|
| **Tumor Size (cm)** | **0.79 ± 0.6 (range, 0.1-6.0)** | |
| Type of cancer | Papillary thyroid carcinoma | 996 |
| | Papillary thyroid microcarcinoma | (752, 75.5%) |
| | Follicular thyroid carcinoma | 1 |
| | Hüthle cell carcinoma | 1 |
| | Medullary thyroid carcinoma | 2 |
| Multiplicity (N) | | |
| Single lesion | 769 (76.9%) | |
| Multiple lesion | 231 (23.1%) | |
| Bilaterality (N) | | |
| No | 894 (89.4%) | |
| Yes | 106 (10.6%) | |
| Retrieved lymph node (N) | | |
| Central compartment | 4.62 ± 3.14 (range, 1-28) | |
| Lateral neck | 27.7 ± 11.0 (range, 12-58) | |
| Stage | | |
| T1/T2/T3/T4a | 512 (51.2%)/9(0.9%)/473 (47.3%)/6 (0.6%) | |
| N0/N1a/N1b | 639 (63.9%)/325 (32.5%)/36 (3.6%) | |
| Stage I/III/IVA | 847 (84.7%)/144 (14.4%)/9 (0.9%) | |

conversion. Thus, over time, the indications of robotic bilateral total thyroidectomy were increased and more advanced cases were included (Table 3). Our institution has carefully expanded the indications for robotic thyroidectomy to include those patients with T3 or larger size lesions (< 4 cm) and N1a or N1b (limited metastasis to the lateral neck compartment).[12] Until September 2010, we had performed more than 1700 cases of robotic thyroidectomy, had made several modifications to our original techniques, and conducted several new trials.[11,12]

Initially, robotic thyroidectomy using TAA resembled endoscopic thyroidectomy using 2 separate incisions (at the axilla and anterior chest wall). After performing more than 750 cases of robotic thyroidectomy using 2 separate incisions, we eliminated the anterior chest wall incision and developed a less invasive transaxillary single-incision robotic technique in July, 2009.[11] Using this procedure, dissection and surgical invasiveness have been reduced while maintaining surgical outcomes.

In addition, we attempted to use robotic thyroidectomy for the management of Grave disease and multinodular goiter, which were difficult to manage using an endoscopic method alone due to the large volume of engorged, fragile thyroid tissue. Surgeons with experience of robotic thyroidectomy can successfully extract large thyroid glands with excellent cosmesis without increasing complication rates. In the early period of our endoscopic experiences, we also performed pure endoscopic MRND using conventional endoscopic instruments for papillary thyroid carcinoma with lateral neck node metastasis.[5] Using the da Vinci robotic system, the technical pitfalls and limitations of the endoscopic procedure can be

**TABLE 3.** Clinicopathologic Characteristics of the Patients According to the Periods

| | **First Period (N = 108)** | **Second Period (N = 163)** | **Third Period (N = 273)** | **Fourth Period (N = 456)** |
|---|---|---|---|---|
| Operation type | 108 | 163 | 273 | 456 |
| Less than total thyroidectomy | 88 | 109 | 161 | 269 |
| Total thyroidectomy | 20 | 54 | 112 | 187 |
| Additional MRND | 1 | 4 | 8 | 22 |
| Total operation time | | | | |
| Less than total | 129.07 ± 30.53 | 141.08 ± 42.27 | 119.89 ± 29.54 | 116.01 ± 28.45 |
| Total | 173.44 ± 40.09 | 155.2 ± 29.6 | 149.03 ± 38.2 | 133.87 ± 29.82 |
| Additional MRND | 318 | 261.8 ± 48.2 | 274.75 ± 25.38 | 280.91 ± 47.41 |
| Tumor size (cm) | 0.79 ± 0.64 | 0.8 ± 0.5 | 0.8 ± 0.45 | 0.76 ± 0.52 |
| T stage | | | | |
| T1 | 54 (50%) | 82 (50.3%) | 140 (51.3%) | 236 (51.6%) |
| T2 | | 2 (1.2%) | 1 (0.4%) | 6 (1.3%) |
| T3 | 53 (49%) | 79 (48.5%) | 129 (47.3%) | 212 (46.6%) |
| T4a | 1 (1%) | | 3 (1%) | 2 (0.4%) |
| Central LN (+) rate | 35 (32.4%) | 61 (37.7%) | 113 (41.4%) | 162 (35.5%) |

LN indicates lymph node; MRND, modified radical neck dissection.

 

**TABLE 4.** Perioperative Outcomes of the Patients According to the Periods

| | First Period (N = 108) | Second Period (N = 163) | Third Period (N = 273) | Fourth Period (N = 456) | Total |
|---|---|---|---|---|---|
| Transient hypocalcemia | 3 (3/20, 15%) | 20 (20/54, 37%) | 45 (45/112, 40.1%) | 77 (77/186, 41.4%) | 145 (TT 145/373, 38.8%) |
| Transient voice change | 4 (3.7%) | 7 (4.3%) | 12 (4.4%) | 19 (4.2%) | 42 (4.2%) |
| Permanent RLN injury | | 2 (1.2%) | 1 (0.4%) | | 3 (0.3%) |
| Seroma | 2 (1.9%) | 4 (2.5%) | 10 (3.7%) | 9 (2%) | 25 (2.5%) |
| Hematoma | | 2 (1.2%) | | 3 (0.7%) | 5 (0.5%) |
| Postoperative bleeding | | | | 1 (0.2%) | 1 (0.1%) |
| Chyle leak | | | | 3 (0.7%) | 3 (0.3%) |
| Trachea injury | | | | 2 (0.4%) | 2 (0.2%) |
| Honor syndrome | | | 1 (0.4%) | | 1 (0.1%) |
| Traction injury of lesion side arm | | | 1 (0.4%) | 1 (0.2%) | 2 (0.2%) |

RLN indicates recurrent laryngeal nerve; TT, total thyroidectomy.

overcome. We have performed more than 34 cases of compartment-oriented MRND with acceptable postoperative outcomes and excellent cosmesis.[12]

Although large numbers of results have already been reported, the technical reproducibility of robotic thyroidectomy remains to be proven. Several surgeons have described their initial experiences of robotic thyroidectomy using TAA, and all have emphasized the importance of adequate training and patient selection before starting robotic thyroid surgery.[18–24]

Robotic thyroidectomy is an exciting new technology, but the procedure is complex and the operative field and robotic facilities are unfamiliar, even to surgeons experienced at open thyroidectomy. The procedure requires a complete understanding of approaching routes, anatomy, and robotic instruments, and thus, sufficient training is absolutely necessary and requires careful observation of an expert's technique and animal or cadaveric studies. Patient selection is also crucial for beginner surgeons. During robotic thyroidectomy, a small or average-sized female patient (body mass index < 30) with concerns of neck scarring is probably the best candidate for initial cases. In terms of pathology, a unilateral lesion of a follicular neoplasm (smaller than 5 cm) or single malignant lesions (smaller than 1 cm) without nodal and capsular involvement should be considered. Of course, the double incision method provides beginners added security until they are familiar with the anatomy of the TAA and the manipulation of robotic implements, because the single incision method requires more meticulous adjustment of robotic arms and manipulations of robotic instruments. The gradual and stepwise extension of surgical methods and indications after proper training and sufficient experience provide the best way of optimally applying robotic thyroid surgery. The last point, which the beginner surgeon should keep in mind is the importance of the surgical team approach. Unlike other types of surgery, robotic procedures have 2 surgeons, that is, a console surgeon and field surgeon. Most of the robotic surgical procedures are manipulated by the console surgeon, but the field surgeon is often required to assist, for example, in the adjustment of robotic arms, the application of suction and traction, and gauze insertion and removal. The robotic scrub nurse's role also differs, because they must fully understand the robotic system and mechanical logistics to ensure fast and safe draping and the implementations of robotic instruments. Specialized anesthesiologists are also necessary, and unscrubbed surgical team members should be specialized in the robotic operation and cooperate in the operative theater to ensure safe operation and optimal surgical results.

## CONCLUSIONS

On the basis of considerable experience, we conclude that robotic thyroidectomy using a gasless TAA is a feasible, safe, and promising surgical alternative for selected patients with low-risk thyroid cancer. The inclusion criteria of this technique could be gradually extended to advanced thyroid cancer with experience and future introductions of robotic system or instrumental developments. During a 2-year period, we have performed 1000 consecutive cases of robotic thyroidectomy using gasless TAA in thyroid cancer patients. Much has been learnt by trial and error, and many modifications have been attempted to devise optimal approaches. Nonetheless, these modifications present an ongoing process, as is the development of more advanced robotic facilities.

**TABLE 5.** Treatment Outcomes of the Patients

| | No. | RAI Scan | Serum Tg After 3 mo of RAI | Follow-Up ultrasonography: No Evidence of Recurrence |
|---|---|---|---|---|
| Less than total thyroidectomy with CCND | 627 | | | 263/263 (100%) |
| Total thyroidectomy with CCND (+ MRND) | 373 | Minor residual uptake in the neck (209/209 100.0%) | < 1.0 (ng/mL):142/209(67.9%)<br>1.0 (ng/mL):67/209 (32%) (mean Tg:4.06 ± 2.31 ng/mL) | 60/60 (100%) |

MRND indicates modified radical neck dissection; RAI, radioactive iodine.

 

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