Single-port Transaxillary Robotic Radical Neck Dissection (STAR-RND): Initial Experience of 30 Cases

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Abstract

This study aimed to demonstrate the usefulness of single-port transaxillary robotic radical neck dissection (STAR-RND) for metastatic thyroid cancer, and its potential to make small and invisible surgical wounds possible compared to open modified radical neck dissection.

Between January 2020 and July 2021, 30 thyroid cancer patients who underwent lateral neck dissection surgery with the da Vinci SP at Yonsei University Health System (Seoul, Korea) were studied.

All 30 patients, diagnosed with papillary thyroid cancer were women. The average operating time was 293.80 ± 36.58 (minutes), and the average postoperative hospital stay was 4.77 ± 0.57 (days). All patients were discharged after the expected number of hospitalization days without major complications.

STAR-RND is technically feasible and safe with a short length of the incision. To our knowledge, this is the first report on the use of a single-port robotic system for radical neck dissection.

Introduction

Thyroid cancer has a high incidence and relatively good prognosis. Although the prognosis is generally good, metastasis to the lateral neck lymph nodes is not uncommon, and in such cases, total thyroidectomy and modified radical neck dissection (MRND) is the treatment of choice.¹ MRND inevitably leads to extensive scarring of the neck, and various efforts to reduce it have been made by improving the surgical technique, particularly since thyroid cancer is characteristically prevalent in young women. With the introduction of robotic surgery, better cosmetic results can be achieved. In addition, several previous studies have confirmed that transaxillary robotic MRND is not significantly different from open surgery in terms of the surgical and oncologic outcomes.^{2,3}

The Da Vinci SP system with a single port has been newly introduced, and has since been used in a variety of fields. The biggest advantage is that surgery is possible even in a narrow and deep space, as three multi-joint robotic arms and cameras are docked through a single port, making smaller incisions possible. Since it was first introduced in 2018 at this institution, more than 200 thyroid surgeries have been performed using this system.^{4,5} Furthermore, by applying this system to RND surgery, which inevitably requires a large incision, surgical results that are not different from conventional robotic surgery and better cosmetic results can be obtained with only a small incision of size 5 cm. In this paper, we aimed to introduce single-port transaxillary robotic radical neck dissection (STAR-RND), and analyze the surgical outcome.

Results

A total of 30 women were diagnosed with PTC with lateral neck metastasis, and underwent surgery. The mean age was 32.3 ± 7.2 years, and the mean BMI was 21.74 ± 3.89 . All patients underwent bilateral thyroidectomy and unilateral RND, 15 patients on the right and 15 on the left side. Table 1 shows the

baseline clinical characteristics of the patients. The perioperative outcomes of the patients included in the study are summarized in Table 2. The mean number of postoperative hospital days was 4.77 ± 0.57 , mean total operating time was 293.80 ± 36.58 minutes, and mean robotic procedure time was 191.80 ± 33.35 minutes. The average number of retrieved lymph nodes was 34.60 ± 8.70 , and the average size of the largest lymph node was 8.27 ± 3.92 mm. RAI ablation with a mean dose of 140 mCi has been performed in 20 patients so far, and the mean post-RAI serum Tg level was 7.08 ± 10 (Table 2).

Table 1
Baseline clinicopathologic characteristics

Characteristics	Value	
Patients numbers	30	
Sex (% of female)	100	
Age (years)	32.27 ± 7.20	
BMI	21.74 ± 3.89	
Op site	Rt	15 (50%)
	Lt	15 (50%)
Pathology (% of PTC)	100	
Largest tumor size (mm)	14.40 ± 7.91	
BMI : Body mass index, Op : Operation, Rt. : Right, Lt : Left, PTC : Papillary thyroid cancer		

Table 2
Perioperative & Surgical oncologic outcomes

Perioperative outcome	Value
POD (days)	4.77 ± 0.57
Total operation time (mins)	293.80 ± 36.58
Robotic procedure time (mins)	191.80 ± 33.35
Working space time (mins)	54.10 ± 14.14
Number of Harvested LNs	34.60 ± 8.70
Number of Positive LNs	8.03 ± 5.19
Largest LN size (mm)	8.27 ± 3.92
Post – RAI off Tg (ng / mL) (only 20 patients, mean dose : 140 mCi.)	7.08 ± 10.29
POD : Postoperative day, LN : Lymph node, RAI : Radioactive iodine, Tg : Thyroglobulin	

Postoperative complications were transient voice change, minor chyle leakage without intervention, and wound seroma in one case each. Transient hypoparathyroidism occurred in six cases, but levels recovered to the normal range in all patients. There were no cases of permanent hypoparathyroidism, RLN injury, or bleeding (Table 3).

Table 3
Postoperative complications

Complications	Number of cases
RLN injury	0
Transient voice change	1 (3.3%)
Chyle leakage	1 (3.3%)
Bleeding	0
Wound seroma	1 (3.3%)
Horner syndrome	0
Arm movement disorder	0
Hypoparathyroidism	
Transient	6 (20%)
Permanent	0
RLN : Recurrent laryngeal nerve	

Discussion

Since the introduction of robot-assisted endoscopic thyroid surgery by Chung et al.⁶ in 2007, more than 8,400 operations (Jun 2021), including more than 500 cases of robotic MRND have been performed at our institution. Robotic surgery is being used in all fields of thyroid surgery, from hemithyroidectomy to bilateral MRND, and previous studies have shown no significant difference when compared to open surgery.^{2,3,7-11} The biggest advantage of robotic thyroid surgery is that the surgical wound can be made invisible in the neutral position, and there is no difference in the surgical results compared to the conventional methods.

The da Vinci SP system is designed to enable surgery without collision of the robotic arms in a narrow space as three multi-joint robotic arms as well as a camera are inserted into the surgical site as a single trocar. With the introduction of this system, it became possible to reduce the dissection range for the working space as well as to reduce the length of the incision. This system is easy to apply in thyroid surgery where a working space from the armpit incision to the thyroid is essential, and there are many relatively young female patients.

After da Vinci SP system was first introduced in our institution in December 2018, START was implemented and showed excellent results without the occurrence of any fatal complications. Recently, the results of 200 cases of START conducted by a single surgeon were reported. A smaller incision (3.5 cm) is possible through a single port operation, and a clear benefit to the patient is guaranteed as the

operation can be performed with fewer flaps compared to the previous system during thyroidectomy. There is also an effect of reducing fatigue by using a two-step docking method for the surgeon or assistant. Although it was not compared to the previous version of the system or open conventional surgery, the possibility of application and expansion of the new da Vinci SP system was confirmed by the reasonable results obtained pertaining to the surgical outcomes, prognosis of the surgical wound, and the postoperative course.⁵

Since the biggest advantage of robotic thyroid surgery is a surgical wound that is smaller and can be hidden, RND using da Vinci SP can be particularly advantageous. Whether it is an open conventional surgery or surgery using the previous version of the robotic system, RND inevitably results in a neck wound greater than 8 to 10 cm due to the extent of the LN dissection. However, if the da Vinci SP system is used, RND can be performed sufficiently with an incision of 5 cm. Even with a 5-cm incision, a 25-mm-sized SP trocar can be inserted, and the three multi-joint instruments and full-wristed camera can secure sufficient space for the operation without possibility of collision.

In addition to facilitating access to deep, narrow spaces, the ease of docking, undocking, and re-docking is another advantage of the SP. In the previous version system, four robot instruments and four robotic trocars had to be moved by adjusting four joints of the robotic arm, whereas in the SP, all instruments are located in one trocar, so only the trocar needs to be moved. This allows thyroidectomy, RND, and level II dissection to be performed without causing delay in the operative time, and with less labor. In addition, since collision-free movement is possible in a narrow space, by providing a more focused approach and field of view in the surgical site, especially during level II dissection, ease of operation can be provided to the surgeon (Figure 4).

Until now, due to technical difficulties in the da Vinci SP system, ultrasonic vibration energy devices such as harmonic scalpel cannot be made flexible; therefore, Erbe is applied to the Da Vinci SP system. No particular complications have occurred to date despite the unfamiliarity with the new energy source, and it is noteworthy that there are some advantages of using Erbe over harmonic scalpels. In the SP system, both sides of the flexible Maryland dissector can be connected to the Erbe, allowing easy access to any space in the surgical area. Moreover, sharp Maryland forceps facilitate precise dissection and allow for nerve tracing or LN dissection without significant thermal injury. In particular, in dissection and preservation of the spinal accessory nerve, there is a clear advantage over the previous system. However, the superiority of ultrasonic energy and bipolar energy devices in preventing thermal damage has not been confirmed.¹²⁻²³. Sutton et al.²⁴ reported that bipolar energy produces a smaller increase in the temperature than the harmonic scalpel. By using a sharp applicator (Maryland) and multiple, short firings of bipolar energy, we believe that thermal damage can be minimized.

In a previous paper presented at our institution, the functional benefit of robotic MRND compared to open MRND was reported.²⁵ In previous reports, severe adhesions that occur after open RND occur between the platysma muscle and the SCM or strap muscle. In the process of obtaining the skin flap for robotic MRND, the dissection between the SCM and platysma is minimized, with almost no dissection between

the platysma and strap muscle. In addition, if the fascia is well preserved, the dissection between the pectoralis muscle and fat rarely causes serious adhesions; consequently, robotic MRND is more extensive than open MRND but is less functionally invasive. This functional advantage of robotic MRND can be further extended in STAR-RND, which requires a smaller dissection range.

The da Vinci SP system was first introduced in our institution in 2019, and RND using this system has been implemented from 2020, demonstrating a feasible and safe performance so far. No fatal complications have occurred in the operated cases, and the patients' wounds become invisible after 6 months of operation, showing excellent cosmetic results (Figure 5).

The limitations of this paper are the retrospective study design, the experience of a single surgeon, and a lack of comparison of the results between open surgery and surgery using the previous version of the system. However, since this is an early report of the results during the stage of introducing and starting a new system, additional research will be possible in the future as more cases are accumulated. Furthermore, based on it, long-term oncologic outcomes such as survival and recurrence can be analyzed, for which a multi-center prospective study may be required.

Methods

1. Patients

Thirty patients who underwent robotic transaxillary total thyroidectomy and additional robotic MRND for lateral neck lymph node (LN) metastasis using the da Vinci SP robotic system between January 2020 and July 2021 at Yonsei University Health System (Seoul, Korea) were examined. All operations were performed by a single surgeon (Kee-Hyun Nam).

Thyroid cancer patients with minimal invasion of the anterior thyroid capsule and strap muscle or less, and with clinical lateral neck LN metastasis were included. Patients with definite invasion of the adjacent organs (recurrent laryngeal nerve [RLN], esophagus, or trachea) or perinodal infiltration at a metastatic LN were excluded. Bilateral total thyroidectomy with unilateral or bilateral central compartment node dissection (CCND) was performed in all cases.

All patients with clinically palpable lateral neck nodes or a lateral LN with a suspicious ultrasound feature on preoperative staging ultrasonography underwent fine-needle aspiration biopsy (FNAB). The lateral LN metastasis was diagnosed by histological examination of ultrasonography-guided FNAB or based on the thyroglobulin (Tg) levels in the FNAB wash out fluid (FNA-Tg >10 ng/mL, >mean + 2SD of FNA-Tg measured in node negative patients, or greater than serum Tg) from the lateral neck LNs.²⁶

At our institution, we follow the general approaches to lateral neck node dissection for papillary thyroid carcinoma (PTC) (MRND type III, sparing the spinal accessory nerve, sternocleidomastoid muscle [SCM], and internal jugular vein [IJV]). In terms of the dissection extent, the submandibular, parotid, submental, and retroauricular nodes are rarely dissected in PTC,²⁷ and level IIB and VA LNs are not routinely

dissected.^{28,29} However, if suspicious nodes are palpable or identified on preoperative ultrasonography at the I or IIB levels, or among the VA LNs, these compartments are included in the en bloc resection.

Details of the clinical features, operation data, complications, and pathological results were extracted from our institutional database. This study was approved by the Institutional Review Board (IRB) of Severance Hospital (4-2021-0246), and conducted in accordance with the principles of the Declaration of Helsinki. The IRB of Severance Hospital waived the requirement for obtaining informed consent based on the study design of retrospective medical record review.

2. Surgical procedure

2.1 Skin flap creation

The patient was placed in a supine position and given general anesthesia. In order to provide full exposure of the operating space to the surgeon, a backrest was placed under the patient so that the neck could be extended, and the patient's face was turned away from the lesion. The arm on the side of the lesion was draped and kept movable rather than immobilized so that it could be raised or stretched laterally during surgery. Generally, the lesion-side arm was raised during flap dissection and adjusted as needed during the robotic console time. A 5 cm incision was made along the anterior axillary skin line (Figure 1 - A). Flap dissection was performed in the same manner as in general robotic transaxillary thyroidectomy. In previous studies, the detailed procedure has been described.³⁰⁻³² A subcutaneous skin flap is created on the anterior surface of the pectoralis major muscle from the axilla to the clavicle and sternal notch. After crossing the clavicle, the platysma muscle is identified and a subplatysmal skin flap is made. The flap is dissected medially to the anterior border of the SCM. On the lateral side, the trapezius muscle is identified and the anterior side of the muscle is dissected upward. The spinal accessory nerve is identified and traced to where it passes under the surface of the SCM. After dissection of the subplatysmal flap, the posterior branch of the SCM is transected at the clavicle attachment point, and this allows full exposure of the junction area between the IJV and subclavian vein. The external jugular vein is ligated at the crossing point of the SCM. Dissection proceeds upward until the submandibular gland and posterior belly of the digastric muscle are exposed with exposure of the level II area. Then, the IJV and lateral border of the strap muscle are carefully separated, and the thyroid gland is detached from the strap muscle until the contralateral lobe is completely exposed. After flap dissection, the patient's head is moved to the neutral position for bilateral total thyroidectomy. An external retractor which is modified to fit the narrow incision is inserted to maintain the working space.

2.2 Robotic total thyroidectomy with CCND

The overall surgical procedure was similar to single-port transaxillary robotic thyroidectomy (START).⁵ The biggest difference was that one camera and three robotic arms were inserted into a single SP port. The robotic camera was located at the bottom of the trocar, the Cardiere was at the top, and two Maryland dissectors were employed on the left and right sides (Figure 2). As the bipolar energy source, Erbe (Erbe USA Inc, Marietta, GA) in the SWIFT COAG mode at a power level of 4–5 was connected to the bilateral Maryland dissectors. By using bipolar energy, the upper-pole dissection can proceed while

preserving the external branch of the superior laryngeal nerve and the superior parathyroid gland. Subsequently, the ipsilateral RLN was identified and central compartment lymph node dissection was performed simultaneously. The detailed thyroid lobectomy procedure has been presented in a previous study.⁴

Contralateral thyroidectomy was performed in the same manner as described for the medial traction of the contralateral thyroid. While the suction assistant continuously pressed the trachea posteriorly, the contralateral upper pole of the thyroid was pulled downward through the Cardiere grasper, and the superior thyroid vessel was identified and ligated. After upper-pole dissection, the strap muscle and thyroid were completely dissected. The contralateral RLN was identified between the residual thyroid gland and trachea. While tracing the contralateral RLN, the thyroid was dissected from the trachea and extracted through an axillary skin incision. If the contralateral thyroid is deeply located or the trachea is prominent, the operating table can be tilted by 10–15 degrees to achieve better exposure of the contralateral tracheo-esophageal groove.

2.3 Robotic MRND

After thyroidectomy, lateral neck dissection was initiated in the level IV area. The IJV was pulled medially using the Cardiere, and the LN was separated from the IJV. Using two Maryland dissectors, the LN and soft tissues were detached from the anterior to the posterior side of the IJV until the vagus nerve and carotid artery were identified (Figure 3 - A). The IJV dissection progressed upwards from level IV to upper level III, during which the omohyoid muscle was cut at the thyroid cartilage level. From the inferior side, the LN was pulled upwards using the Cardiere to detach it from the junction of the subclavian vein and IJV. Due to the three multi-jointed robotic arms and a full-wristed camera, the difficulty in access due to the clavicle could be minimized. Dissection continued laterally along the subclavian vein, and the inferior belly of the omohyoid muscle was cut where it met the trapezius muscle. The distal part of the external jugular vein (EJV) was then divided with a surgical clip at its junction with the subclavian vein. Level VB dissection of the posterior neck region proceeded in a superomedial direction along the spinal accessory nerve, preserving the brachial plexus, phrenic nerve, and thoracic duct, followed by level IV dissection (Figure 3 - B). The dissection proceeded sequentially from levels VB, IV, III, and upwards to the level IIA area. The external retractor and robotic axis were repositioned after dissection of the level III area for better exposure of the level II area. As a result, the external retractor was reinserted towards the submandibular gland. Being pulled inferolaterally, the specimen was dissected from the anterior surfaces of the carotid artery and IJV, the lateral border of the sternohyoid muscle, and the submandibular gland. Level IIA dissection proceeded upward to the site where the posterior belly of the digastric muscle was exposed. The specimen was extracted through the axillar incision, and fibrin glue was sprayed around the area of the thoracic duct. A 3-mm closed suction drain was inserted and the wound was closed cosmetically. The incision scar following the skin crease was completely covered and invisible in the neutral position.

3. Postoperative management

A closed drain was inserted in all patients to prevent complications from postoperative seroma or bleeding (Figure 1 - B). Patients were discharged after about 4–6 postoperative days when the drainage decreased to less than 50 mL per day. After the initial surgery, all patients received levothyroxine to suppress thyroid secreting hormone (TSH) secretion.

Hypoparathyroidism was defined as a case in which the serum intact parathyroid hormone (PTH) level was below the normal range regardless of the symptoms.

All patients underwent radioactive iodine (RAI) ablation 1 to 3 months after the surgery with measurement of serum concentrations of Tg and whole body scans performed after the RAI ablation.³³

Conclusions

STAR-RND is technically feasible and safe with a short length of the incision. STAR-RND is associated with excellent surgical outcomes along with cosmetic and functional benefits to the patients.

Declarations

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Joon Ho and Kee-Hyun Nam were responsible for conception and design. Joon Ho and Kee-Hyun Nam wrote the manuscript and carried out review and revision of the manuscript. All authors contributed to the provided final approval to submit the manuscript for publication.

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Figures

Figure 1

Operative incision. **A)** Preoperative incision design, **B)** Immediate postoperative wound with closed drain – 5cm along the anterior axillary line

Figure 2

Davinci SP system devices after docking – Three robotic arms and one camera through single SP port

Figure 3

Lateral neck dissection. **A)** Internal jugular vein dissection, **B)** Level 4 & 5 lymph node dissection along spinal accessory nerve. **White Arrow:** Right internal jugular vein, **Black Arrow:** Right spinal accessory nerve

Figure 4

Comparison of the view of Level II dissection. **A)** prior version of da Vinci, **B)** da Vinci SP system.

Black arrow. Right spinal accessory nerve, **White arrow.** Right internal jugular vein

Figure 5

Postoperative wound (postoperative 6 months)