9 Robot-Assisted Transaxillary Thyroidectomy

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Introduction

Since Theodor Kocher transformed thyroid surgery into a safe and reliable procedure, open thyroidectomy has been considered the standard operative approach to the thyroid gland. However, due to increased interest in patient quality of life during recent decades, there has been a need for advanced surgical techniques that minimize the unattractive, conspicuous scar in the neck area that results from a thyroidectomy. Accordingly, various endoscopic techniques have been developed using smaller cervical or remote access incisions.

In 2001 we introduced the gasless, endoscopic transaxillary thyroidectomy approach. Through 2007 more than 650 of these cases have been performed successfully. However, an endoscopic thyroidectomy has some limitations in obtaining adequate visualization. Additionally, precise, meticulous manipulation of the surgical tissues can be challenging due to certain shortcomings, including two-dimensional imaging, the absence of tactile sensation and the use of unsophisticated endoscopic instruments in the narrow working space.

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With the innovation of robotic technology, application of surgical robotic systems has enabled surgeons to overcome the abovementioned shortcomings of endoscopic procedures by providing three-dimensional images in magnified view and more dexterous and accurate instrument movements. Since 2007, when we first introduced robot-assisted transaxillary thyroidectomy (RAT), many studies have been performed defining the technical safety, feasibility, and functional or surgical outcomes of robotic thyroid surgery. With greater experience, robotic thyroidectomy can be performed through a single incision, and the indication of the procedure extended to include thyroid carcinoma with lateral neck node metastasis or Graves' disease. In this chapter, the specific indications for and detailed method of robot-assisted transaxillary thyroidectomy for the management of thyroid disease are described.

Selection Criteria

Surgeon and Specialized Team

Surgeons should be experienced at conventional open thyroid gland surgery before conducting robotic procedures. They should be fully acquainted with the relevant anatomy because it may be unfamiliar to them due to a different access point and a lack of preexisting working space. Before conducting operations in patients, surgeons should also receive sufficient education

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and training (using animals or cadavers) both for developing the working space and in the use of the robot. Furthermore, a surgeon should perform incrementally more challenging cases, starting with straightforward cases and progressing to more advanced cases.

Moreover, robot-assisted transaxillary thyroidectomy is a complex procedure, which is best performed along with a specialized robotic team. The team should consist of an anesthesiologist, an operating room staff (bedside assistant and nurse), and a robotic technician. All team members should become familiar not only with the robot (including robotic devices, instrument assignments, setup, and operation and entry/exit) but also with the overall flow of the surgery. The robotic system should be tested for normal operation before usage, and a technician should troubleshoot the robot immediately when a system error occurs.

Fig. 9.1 Soft pillow and arm board for patient positioning

Special Equipment

In terms of patient positioning, a soft pillow (for neck extension) and an arm board (placed on the lesion side) attached to the operative table should be prepared (Fig. 9.1). During development of the working space, electrocautery, a vascular DeBakey forceps, and various retractors (army-navy retractors, right-angled retractors, and lighted breast retractors) are used for subcutaneous flap dissection and elevation (Fig. 9.2). For maintaining the working space, we use an external retractor we designed (Chung's retractor; Fig. 9.3).

For the robotic procedure, a da Vinci S or Si system (Intuitive, Inc., Sunnyvale, CA, USA) can be used. Three robotic instruments (5-mm Maryland dissector, 8-mm ProGrasp forceps, and 5-mm Harmonic curved shears) and a

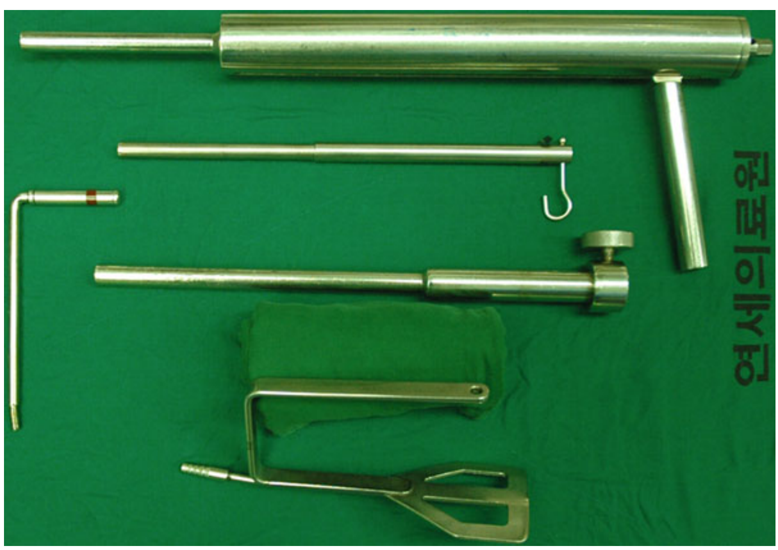

Fig. 9.2 External retractor for maintaining the working space

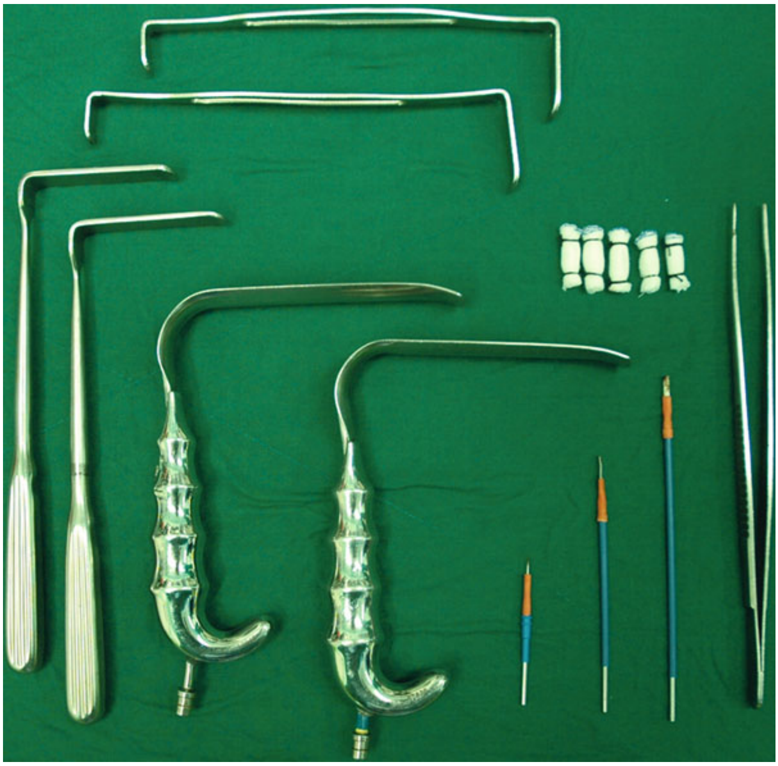

Fig. 9.3 Devices for developing the working space

dual-channel camera (30° down) are needed (Table 9.1). Small rolled-up gauzes are used for control of bleeding.

Surgical Indications

Based on the feasibility and safety of endoscopic transaxillary thyroidectomy for low-risk papillary thyroid microcarcinomas, the initial eligibility criteria for RAT were limited to well-differentiated thyroid carcinomas with a tumor size of ≤2 cm (without extrathyroidal tumor extension) or to benign tumors with a size of ≤5 cm. At that time, due to the possibility of injuring critical structures (trachea, esophagus, or recurrent laryngeal nerve [RLN]) during the procedure, lesions located deep in the thyroid bed, especially those adjacent to the tracheoesophageal groove, were considered ineligible. With greater experience the indications have expanded and now include advanced cancer cases, such as those with definite adjacent muscle invasion, RLN invasion, and lateral neck node metastasis.

Table 9.1 Special equipment for the robot-assisted transaxillary thyroidectomy

Patient positioning (Fig. 9.1)
Soft pillow
Arm board
Development of working space (Fig. 9.2)
Electrocautery with short, regular, and long tip
Vascular DeBakey
Army-navy retractor × 2
Right-angled retractors × 2
Breast lighted retractor × 2
Maintenance of working space (Fig. 9.3)
Chung's retractor
Table mount and suspension device (BioRobotics, Seoul, Korea, or Marina Medical, Sunrise, FL)
Robotic procedure
5-mm Maryland dissector
8-mm ProGrasp forceps
5-mm Harmonic curved shears
Dual-channel 30° endoscope (used in the rotated down position)
Assistant instruments
Ethicon Endopath graspers and forceps
Ethicon Endopath suction irrigator
Miscellaneous
Small rolled-up gauzes

Currently, the eligibility criteria for RAT are as follows: (1) benign tumor or follicular neoplasm with a size of ≤5 cm, (2) mild- to moderate-size Graves' goiters, and (3) well-differentiated thyroid carcinomas with a primary tumor size of ≤4 cm and minimal invasion by the primary tumor into the anterior thyroid capsule and strap muscles. The contraindications for RAT include (1) definite tumor invasion into an adjacent organ (RLN, esophagus, major vessels, or trachea), (2) metastasis to multiple lymph nodes in multiple levels of the lateral neck, and (3) perinodal infiltration around a metastatic lymph node. Prior to surgery, all patients should be evaluated by an ultrasonography-guided fine needle aspiration biopsy and the clinical stage should be checked by a staging neck ultrasonography or computed tomography scan.

Procedural Details

Patient Positioning

The patient is placed in the supine position with neck extension by inserting a soft pillow under the shoulders. The lesion-side arm is raised to shorten the distance between the axillary incision and the target area. To avoid brachial plexus paralysis, the arm is extended naturally within the range of shoulder motion and should not be fixed by force. A modified arm position or a laterally abducted position is helpful with a stiff shoulder.

Creating Working Space

The neck region is relatively narrow and encases many vital structures without a natural body cavity, therefore, making an artificial space for accessing the thyroid gland is demanding. Additionally, sufficient working space is essential for optimizing the use of the robot.

The working space consists of the outer and inner spaces. The outer space is the channel for approaching the target area and is bound by a subcutaneous skin flap and the pectoralis major muscle. The robotic dissection is performed in the inner space, which is surrounded by strap muscles and the sternal head of sternocleidomastoid (SCM) muscle ventrally and by the trachea, major blood vessels, and the clavicular head of SCM muscle dorsally (Fig. 9.4a).

The reference landmarks are (1) the sternal notch, (2) a transverse line from the sternal notch laterally to the axilla (inferior limit of the incision), (3) the upper limit of the lesion side of the thyroid gland, (4) a 70–80° oblique line from the upper pole of the thyroid to the axilla (superior limit of the incision), and (5) the medial border of the ipsilateral SCM muscle (Fig. 9.4b). A 5- to 6-cm vertical skin incision is made in the axillary area. The precise location of this incision (in a cephalad-caudad vector) should be based on the height of the upper limit of the thyroid gland. Additionally, it should be placed so that it is completely covered with the arm in the anatomic position. The subcutaneous skin flap from the axilla to the anterior neck area is dissected over the anterior surface of the pectoralis major muscle and clavicle. To develop sufficient working space without tension, the subcutaneous and subplatysmal flaps should be dissected up to level of the upper limit of thyroid gland and to the superior end of the incision. In addition, dissection should be carried to 2 cm inferior to the level of the sternal notch and to the lower edge of the incision. After the SCM muscle is exposed, the thyroid compartment is approached through the avascular space between the two heads of the SCM muscle and deep to the strap muscle. Dissection should continue until the contralateral side of the thyroid gland is exposed. The omohyoid muscle is fully mobilized and retracted ventrally and the clavicular head of the SCM muscle is dissected fully to the bottom of inner space so as not to block the surgeon's view. To assure sufficient inner working space, all soft tissues and the anterior surface of the thyroid gland are completely detached from the dorsal part of the strap muscles. The external retractor (Chung's retractor) is inserted through the skin incision to maintain the working space and placed between the thyroid gland and the strap muscles. Experience has shown that to achieve adequate working space, the height of incision entrance should be ≥4 cm and the space between the retractor blade and the

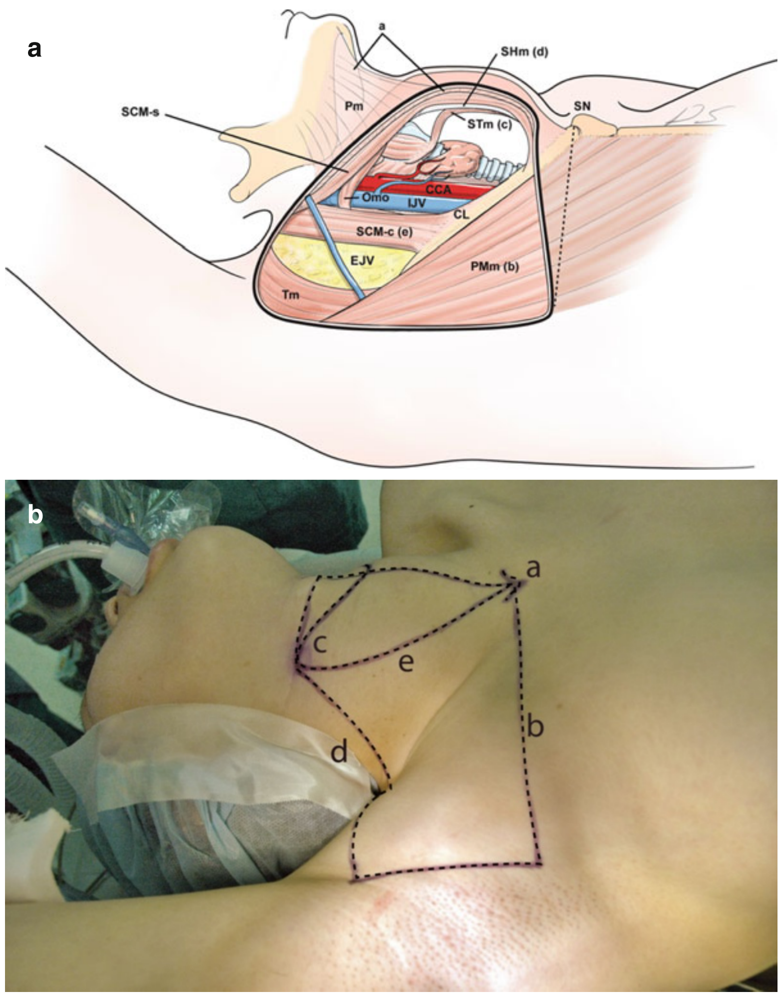

Fig. 9.4 (**a**) The working space of the robotic thyroidectomy consists of the outer and the inner spaces. The outer space is bound by a subcutaneous skin flap (*a*) and the pectoralis major muscle (*b*). The inner space is surrounded by strap muscles (*c*) and the sternal head of sternocleidomastoid (*SCM*) muscle (*d*) ventrally and by the trachea, major vessels, and the clavicular head of SCM muscle (*e*) dorsally. (**b**) The reference landmarks of robotic thyroidectomy: (*a*) the sternal notch, (*b*) a transverse line from the sternal notch laterally to the axilla (inferior limit of the incision), (*c*) the upper limit of the lesion side of the thyroid gland, (*d*) 70–80° oblique line from the thyroid upper pole laterally to the axilla (superior limit of the incision), and (*e*) the medial border of the ipsilateral SCM muscles. *Pm* platysma muscle, *STm* sternothyroid muscle, *SHm* sternohyoid muscle, *SN* sternal notch, *CCA* common arotid artery, *IJV* internal jugular vein, *CL* clavicle, *EJV* external jugular vein, *PMm* pectoralis major uscle, *Omo* omohyoid muscle, *Tm* trapezius muscle, *SCM-s* sternal head of SCM muscles, *SCM-c* clavicular head of SCM muscles

anterior surface of the thyroid gland should be ≥1 cm.

Robotic Docking

The patient cart is placed on the side contralateral to the axillary incision. To avoid inter-arm collisions, axis alignment is important. The operative table should be positioned slightly oblique, and the center column of patient cart should be aligned with the long axis of the external retractor.

Two-Incision Method

Robot-assisted transaxillary thyroidectomy was initially performed using a two-incision technique. The second incision is made on the anterior chest wall on the side of the thyroid pathology, 2–4 cm superior and 6–8 cm medial to the nipple, and away from the sternum. Of the four robotic arms, three arms are inserted through the axillary incision and the remaining arm is inserted through the anterior chest wall. The 30° down dual-channel endoscope is placed on the central arm and introduced in a downward to upward direction. It should be in line with both the center column of the patient cart and the long axis of the external retractor. The 8-mm Harmonic curved shears and the 5-mm Maryland dissector are placed on both sides of the scope and introduced in an upward to downward direction. The external third joints of these robotic arms should form an inverted triangle shape. The ProGrasp forceps, on the anterior chest arm, is inserted toward the targeted area and is placed laterally to the sternal head of the sternocleidomastoid (SCM) muscle.

Single-Incision Method

After performing more than 700 cases of the two-incision technique, we transitioned to using a single axillary incision. All four robotic arms are inserted through the axillary incision. As mentioned above, the dual-channel endoscope is placed at the center of the incision, aligned with the axis of the external retractor. To prevent interference between the robotic arms, the ProGrasp forceps are inserted caudal to the endoscope and positioned at the ceiling of the working space. The tip of the ProGrasp forceps is slid fully into the working space, and its external third joint moves backward and works in a different plane than the other three robotic arms. The 5-mm Maryland dissector and the 5-mm Harmonic curved shears are both inserted at the lateral border of the incision. From the outside, the arms form an inverted triangle with the external third joint of the endoscope.

Thyroidectomy (Dissection)

The surgical principles of robotic thyroidectomy and conventional open thyroidectomy are the same. Optimal dissection planes can be obtained by traction and countertraction using both a Maryland dissector and ProGrasp forceps, and all dissections and vascular ligations are performed using the Harmonic curved shears. The dissection proceeds in a superior to inferior direction. The upper pole of the thyroid gland is drawn in a medio-inferior direction using the ProGrasp forceps, and the superior thyroid vessels are ligated individually using the Harmonic curved shears (Fig. 9.5a). All vessels are identified and ligated close to the thyroid gland to avoid injuring the external branch of the superior laryngeal nerve. The thyroid gland is carefully detached from the cricopharyngeal and cricothyroid muscles by repeated re-grasping, which leads to gradual dissection of thyroid tissue. The upper pole dissection is continued until the superior parathyroid gland is exposed and released (Fig. 9.5b). The superior parathyroid gland is carefully preserved by avoiding lateral thermal spread from the Harmonic curved shears during dissection. For inferior pole dissection, the thyroid gland is pulled in a superior-medial direction. Before performing a central compartment neck dissection (CCND), the ipsilateral RLN is identified near the common carotid artery. After identifying the RLN, the ipsilateral CCND is started at the lateral side of the central compartment and is carried to the sternal notch inferiorly (Fig. 9.5c). All the soft tissues are removed from the paratracheal and pretracheal areas. The central neck contents and the inferior pole of thyroid gland are pulled upward and the whole course of the RLN is traced distally and preserved. The inferior thyroid artery is divided close to the thyroid gland using the Harmonic curved shears. Care is needed to avoid direct or indirect thermal injury to the RLN. The thyroid gland is meticulously peeled off the trachea using the Harmonic curved shears. In cases of total thyroidectomy, a contralateral lobectomy is performed by subcapsular dissection. The contralateral dissection is performed in the same order as that described for the ipsilateral side. The contralateral upper pole is drawn in an inferomedial direction using the ProGrasp forceps. The superior thyroid vessels are ligated close to the thyroid gland with subcapsular dissection (Fig. 9.5d). After detaching the upper

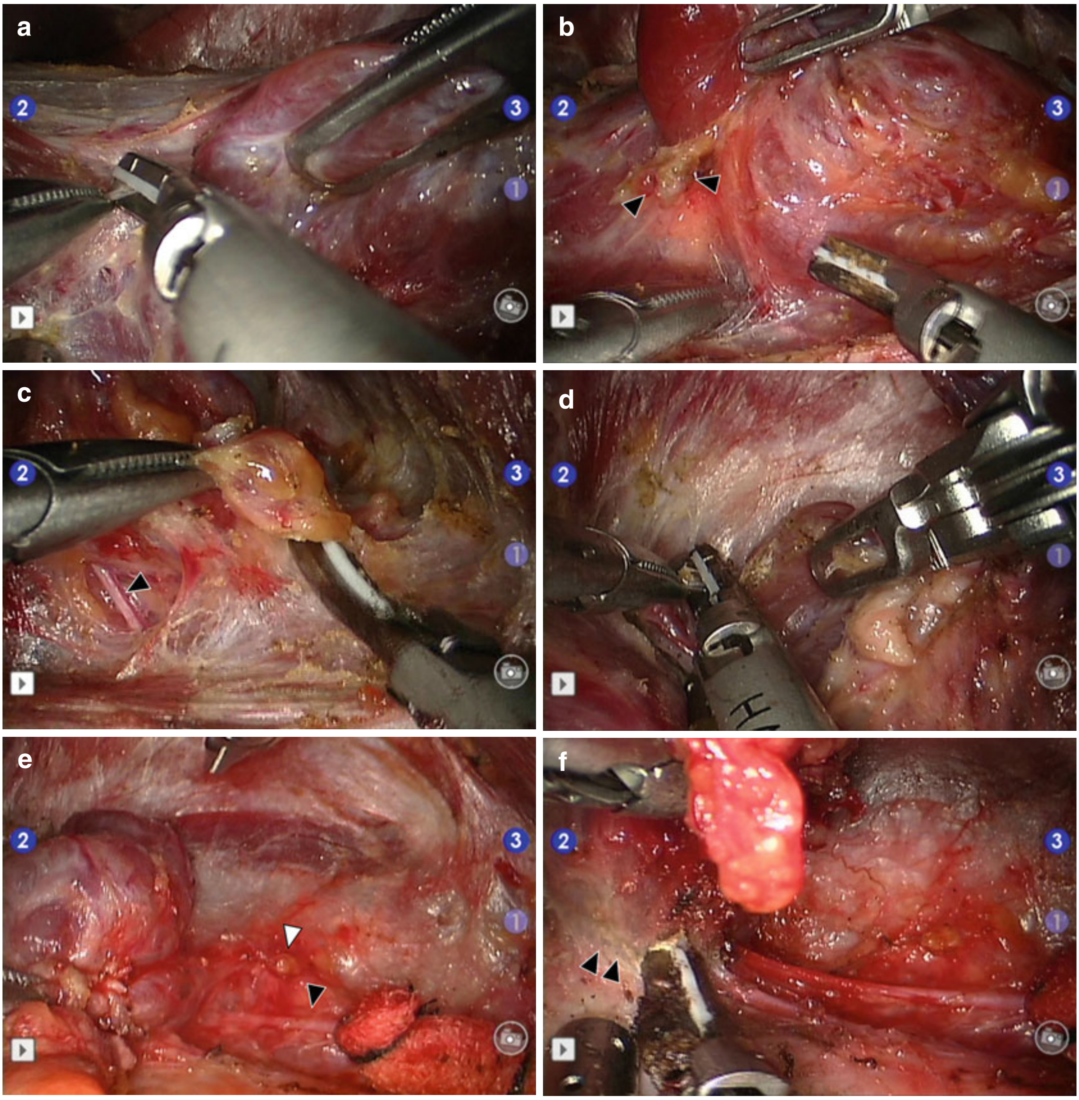

Fig. 9.5 The robotic view of a total thyroidectomy. The right side is completed first (**a**–**c**) and then the left (**d**–**f**). The patient's head is to the left and the feet to the right. (**a**) As the right thyroid lobe is retracted inferiorly, the ipsilateral superior thyroid vessels are ligated. (**b**) The right thyroid lobe is retracted medially and the superior parathyroid gland (*arrow heads*) is identified and preserved. (**c**) As the central neck is dissected, the ipsilateral RLN (*arrow head*) is clearly seen. (**d**) The contralateral (*left*) superior thyroid vessels are ligated. (**e**) The contralateral inferior parathyroid gland (*white arrow head*) and RLN (*black arrow head*) are seen during the contralateral inferior pole dissection. The lobe is being retracted superiorly. The trachea is seen at the bottom of the figure. (**f**) The dissection of the contralateral Berry's ligament area (*arrow heads*) is shown

pole from the cricothyroid muscle and preserving the superior parathyroid gland, the inferior pole dissection is completed. At the inferior pole, the inferior parathyroid gland and the contralateral RLN are preserved by subcapsular dissection (Fig. 9.5e). The contralateral RLN usually runs parallel to the dissection plane and is safe with subscapular dissection. After the inferior pole dissection, the thyroid gland is retracted medially using the ProGrasp forceps, and the lateral portion of the thyroid gland is detached until Berry's ligament is exposed. The thyroid gland is then retracted ventrally and the dissection proceeds in a medial-to-lateral direction, following the RLN until its insertion site (Fig. 9.5f). The specimen is extracted through the axillary incision, and a 3-mm closed suction drain is inserted into the surgical bed.

The single-incision method is performed in the same manner as the two-incision technique except for the use of the ProGrasp forceps. Because all four robotic arms are inserted through a single axillary incision, inter-arm collisions are prevented by using a slightly modified method. The ProGrasp forceps is placed as described above and its instrument arm is positioned in a different plane. The console surgeon uses only the wristed motions of the ProGrasp forceps, minimizing the movement of the instrument arm and its external joints.

Outcomes

Overall, outcomes have been excellent. However, complications can occur. Complications of RAT are classified as those that can occur with conventional thyroidectomy and CCND and those that are related to the robotic method itself. The prevalence of complications related to thyroidectomy and CCND (hypoparathyroidism (transient or permanent), RLN injury (transient or permanent), hematoma, and seroma formation) is similar with that of conventional open thyroidectomy. The complications specific to the RAT method include lesion-side brachial plexus paralysis, skin flap injury, and tracheal wall injury. The brachial plexus paralysis is a troublesome complication regarded as a stretch-induced neuropathy and is related to the patient's positioning. The symptoms are characterized by arm weakness and paresthesia, and these typically improve gradually over several weeks with conservative management. As mentioned previously, to prevent this type of injury, the arm ipsilateral to the lesion should be extended without tension. In cases of a patient with a stiff shoulder, a modified arm position is recommended. For patients with a frozen shoulder or limited shoulder motion, in order to avoid interference between the arm and the robotic instruments, the laterally abducted position is recommended. The monitoring of somatosensory-evoked potential responses for radial, ulnar, and median nerves can be helpful in high-risk patients. A skin injury during flap dissection can occur, particularly when the surgery is being performed by an inexperienced surgeon. The cosmetic expectation of a patient undergoing robotic thyroidectomy is very high; therefore, this complication can undermine the rationale for employing this technique. Therefore, a careful subplatysmal flap dissection should be performed with full understanding of the anatomy, particularly in the lateral neck area where the flap is thinnest. The prevalence of tracheal injury requiring primary repair in this approach is reported to be 0.3 %. A tracheal injury usually occurs during the process of peeling the thyroid gland off the trachea, from the vibration and heat produced by the Harmonic curved shears. Lifting the gland off the trachea helps to prevent this complication and the active blade of the Harmonic curved shears should be not applied directly to the tracheal wall for an extended period of time. Tracheal wall injury can be managed by primary suture or placement of a muscle flap using the robotic instruments.

Conclusions

The application of robotic technology to thyroid disease enables meticulous surgical treatment and frees the patient from a conspicuous neck scar. With instrumental advances and more experience, RAT will expand its indications and may replace the conventional open maneuver in more advanced cases.

Recommended Reading

Chang L, Satava RM, Pellegrini CA, Sinanan MN. Robotic surgery: identifying the learning curve through objective measurement of skill. Surg Endosc. 2003;17(11):1744–8. Epub 2003/09/06.

Duncan TD, Ejeh IA, Speights F, Rashid QN, Ideis M. Endoscopic transaxillary near total thyroidectomy. JSLS. 2006;10(2):206–11. Epub 2006/08/03.

Gagner M. Endoscopic subtotal parathyroidectomy in patients with primary hyperparathyroidism. Br J Surg. 1996;83(6):875. Epub 1996/06/01.

Herrell SD, Smith Jr JA. Robotic-assisted laparoscopic prostatectomy: what is the learning curve? Urology. 2005;66(5 Suppl):105–7. Epub 2005/10/01.

Holsinger FC, Terris DJ, Kuppersmith RB. Robotic thyroidectomy: operative technique using a transaxillary endoscopic approach without CO_2 insufflation. Otolaryngol Clin N Am. 2010;43(2):381–8, ix–x. Epub 2010/06/01.

Ikeda Y, Takami H, Sasaki Y, Takayama J, Niimi M, Kan S. Comparative study of thyroidectomies. Endoscopic surgery versus conventional open surgery. Surg Endosc. 2002;16(12):1741–5. Epub 2002/07/26.

Ikeda Y, Takami H, Sasaki Y, Takayama J, Niimi M, Kan S. Clinical benefits in endoscopic thyroidectomy by the axillary approach. J Am Coll Surg. 2003; 196(2):189–95. Epub 2003/02/22.

Inukai M, Usui Y. Clinical evaluation of gasless endoscopic thyroid surgery. Surg Today. 2005;35(3): 199–204. Epub 2005/03/18.

Jeong JJ, Kang SW, Yun JS, Sung TY, Lee SC, Lee YS, et al. Comparative study of endoscopic thyroidectomy versus conventional open thyroidectomy in papillary thyroid microcarcinoma (PTMC) patients. J Surg Oncol. 2009;100(6):477–80. Epub 2009/08/05.

Kandil EH, Noureldine SI, Yao L, Slakey DP. Robotic transaxillary thyroidectomy: an examination of the first one hundred cases. J Am Coll Surg. 2012;214: 558–64. Epub 2012/03/01.

Kang SW, Jeong JJ, Yun JS, Sung TY, Lee SC, Lee YS, et al. Gasless endoscopic thyroidectomy using transaxillary approach; surgical outcome of 581 patients. Endocr J. 2009a;56(3):361–9. Epub 2009/01/14.

Kang SW, Jeong JJ, Nam KH, Chang HS, Chung WY, Park CS. Robot-assisted endoscopic thyroidectomy for thyroid malignancies using a gasless transaxillary approach. J Am Coll Surg. 2009b;209(2):e1–7. Epub 2009/07/28.

Kang SW, Jeong JJ, Yun JS, Sung TY, Lee SC, Lee YS, et al. Robot-assisted endoscopic surgery for thyroid cancer: experience with the first 100 patients. Surg Endosc. 2009c;23(11):2399–406. Epub 2009/03/06.

Kang SW, Lee SC, Lee SH, Lee KY, Jeong JJ, Lee YS, et al. Robotic thyroid surgery using a gasless, transaxillary approach and the da Vinci S system: the operative outcomes of 338 consecutive patients. Surgery. 2009d;146(6):1048–55. Epub 2009/11/03.

Kang SW, Lee SH, Ryu HR, Lee KY, Jeong JJ, Nam KH, et al. Initial experience with robot-assisted modified radical neck dissection for the management of thyroid carcinoma with lateral neck node metastasis. Surgery. 2010;148(6):1214–21. Epub 2010/12/08.

Kang SW, Lee SH, Park JH, Jeong JS, Park S, Lee CR, et al. A comparative study of the surgical outcomes of robotic and conventional open modified radical neck dissection for papillary thyroid carcinoma with lateral neck node metastasis. Surg Endosc. 2012;26:3251–7. Epub 2012/06/01.

Kuppersmith RB, Holsinger FC. Robotic thyroid surgery: an initial experience with North American patients. Laryngoscope. 2011;121(3):521–6. Epub 2011/02/24.

Lee J, Chung WY. Current status of robotic thyroidectomy and neck dissection using a gasless transaxillary approach. Curr Opin Oncol. 2012;24(1):7–15. Epub 2011/11/15.

Lee J, Nah KY, Kim RM, Ahn YH, Soh EY, Chung WY. Differences in postoperative outcomes, function, and cosmesis: open versus robotic thyroidectomy. Surg Endosc. 2010;24(12):3186–94. Epub 2010/05/22.

Lee S, Ryu HR, Park JH, Kim KH, Kang SW, Jeong JJ, et al. Excellence in robotic thyroid surgery: a comparative study of robot-assisted versus conventional endoscopic thyroidectomy in papillary thyroid microcarcinoma patients. Ann Surg. 2011a;253(6): 1060–6. Epub 2011/05/19.

Lee J, Kang SW, Jung JJ, Choi UJ, Yun JH, Nam KH, et al. Multicenter study of robotic thyroidectomy: short-term postoperative outcomes and surgeon ergonomic considerations. Ann Surg Oncol. 2011b;18(9): 2538–47. Epub 2011/03/05.

Lee J, Lee JH, Nah KY, Soh EY, Chung WY. Comparison of endoscopic and robotic thyroidectomy. Ann Surg Oncol. 2011c;18(5):1439–46. Epub 2010/12/25.

Lee J, Yun JH, Nam KH, Choi UJ, Chung WY, Soh EY. Perioperative clinical outcomes after robotic thyroidectomy for thyroid carcinoma: a multicenter study. Surg Endosc. 2011d;25(3):906–12. Epub 2010/08/25.

Lee J, Yun JH, Nam KH, Soh EY, Chung WY. The learning curve for robotic thyroidectomy: a multicenter study. Ann Surg Oncol. 2011e;18(1):226–32. Epub 2010/08/04.

Lee J, Na KY, Kim RM, Oh Y, Lee JH, Lee JS, et al. Postoperative functional voice changes after conventional open or robotic thyroidectomy: a prospective trial. Ann Surg Oncol. 2012a;19(9):2963–70. Epub 2012/04/27.

Lee S, Ryu HR, Park JH, Kim KH, Kang SW, Jeong JJ, et al. Early surgical outcomes comparison between robotic and conventional open thyroid surgery for papillary thyroid microcarcinoma. Surgery. 2012b; 151(5):724–30. Epub 2012/01/31.

Miccoli P, Berti P, Raffaelli M, Conte M, Materazzi G, Galleri D. Minimally invasive video-assisted thyroidectomy. Am J Surg. 2001;181(6):567–70. Epub 2001/08/22.

Nam KH, Owen R, Inabnet WB. Prevention of complications in transaxillary single-incision robotic thyroidectomy. Thyroid. 2012;22:1266–74. Epub 2012/08/08.

Ryu HR, Kang SW, Lee SH, Rhee KY, Jeong JJ, Nam KH, et al. Feasibility and safety of a new robotic thyroidectomy through a gasless, transaxillary single-incision approach. J Am Coll Surg. 2010;211(3):e13–9. Epub 2010/08/31.

Shimizu K, Kitagawa W, Akasu H, Tanaka S. Endoscopic hemithyroidectomy and prophylactic lymph node dissection for micropapillary carcinoma of the thyroid by using a totally gasless anterior neck skin lifting method. J Surg Oncol. 2001;77(3):217–20. Epub 2001/07/17.

Tae K, Ji YB, Cho SH, Lee SH, Kim DS, Kim TW. Early surgical outcomes of robotic thyroidectomy by a gasless unilateral axillo-breast or axillary approach for papillary thyroid carcinoma: 2 years' experience. Head Neck. 2012a;34(5):617–25.

Tae K, Kim KY, Yun BR, Ji YB, Park CW, Kim DS, et al. Functional voice and swallowing outcomes after robotic thyroidectomy by a gasless unilateral axillo-breast approach: comparison with open thyroidectomy. Surg Endosc. 2012b;26(7):1871–7.

Tan CT, Cheah WK, Delbridge L. "Scarless" (in the neck) endoscopic thyroidectomy (SET): an evidence-based review of published techniques. World J Surg. 2008;32(7):1349–57. Epub 2008/03/25.

Welbourn RB. Highlights from endocrine surgical history. World J Surg. 1996;20(5):603–12. Epub 1996/06/01.

Yoon JH, Park CH, Chung WY. Gasless endoscopic thyroidectomy via an axillary approach: experience of 30 cases. Surg Laparosc Endosc Percutan Tech. 2006; 16(4):226–31. Epub 2006/08/22.