Robot-Assisted Neck Surgery

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12.1 Introduction

Conventional surgeries for various surgically treatable neck tumors adopted the transcervical approach to "open up" the surgical field which were sometimes unfavorable for the patient since the resulting scars were perceived disfiguring and the surgeries also caused various postoperative morbidities. The neck is the most easily recognized and exposed area, and the psychosocial impact may be even more displeasing if a large incisional scar has been created due to neck dissection for head and neck cancer with cervical metastasis. Furthermore, conventional transcervical approach-based surgeries often require large amount of normal tissue dissection just for the purpose of surgical access which could lead to prolonged postoperative recovery and various degrees of functional deterioration.

Consequently in order to reduce the extent of surgical trauma and minimize these surgery-related morbidities, numerous surgical approaches from a distant port have been developed. These so-called remote-access surgeries were founded upon the technological advances of endoscopy and surgical robotics. Based on the early attempts of robotic facelift thyroidectomies by Terris et al. [1–5] and the authors' extensive surgical experience on former endoscopic and robotic gasless transaxillary thyroidectomy [6, 7], we have extrapolated the application of the RA approach to nearly all aspects of head and neck surgery with the aid of the robotic system (Da Vinci Si Robotic System; Intuitive Surgical Inc., Sunnyvale, CA) [8–17]. The authors have seen the promising role of RA approach from its versatile applications.

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12.2 Fundamental Concept

The modified facelift (MFL) incision when performing conventional parotidectomy forms the basis for RA incision. The only difference between the MFL and RA incision is the existence of the preauricular limb (Fig. 12.1). Most of the time this robotic procedure can be conducted with the RA incision; however, if there is a necessity for extended access or if a parotidectomy is simultaneously performed at the same side, the MFL incision can be made. Since the surgical access port is remotely placed, common procedures of working space creation and pre-robotic gross dissection are universally applied to all RA robotic neck surgeries.

12.2.1 Universal Surgical Sequence

First, a RA incision is made and an appropriate working space is established (Figs. 12.2 and 12.3).

Next, a self-retaining retractor (L & C Bio, Seongnam-si, Korea) is placed to maintain the working space and then certain surgical steps of gross dissection under the naked eye are conducted beforehand, to move on to the robotic dissection. Recently, this procedure can also be done at the surgeon's robotic console with the help of the upgraded da Vinci Xi system, since an extra robotic instrumental arm can be inserted through the RA port (Fig. 12.4).

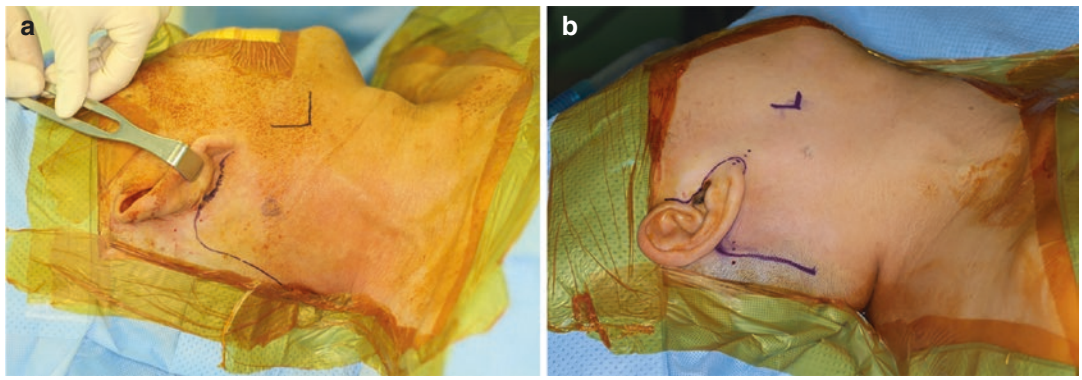

Fig. 12.1 The position of the patient is supine with the head rotated to the contralateral side of the approach just as you would perform a parotidectomy. The neck, however, is relaxed in its natural position and not extended with shoulder rolls. (**a**) Retroauricular incision. (**b**) Modified facelift incision

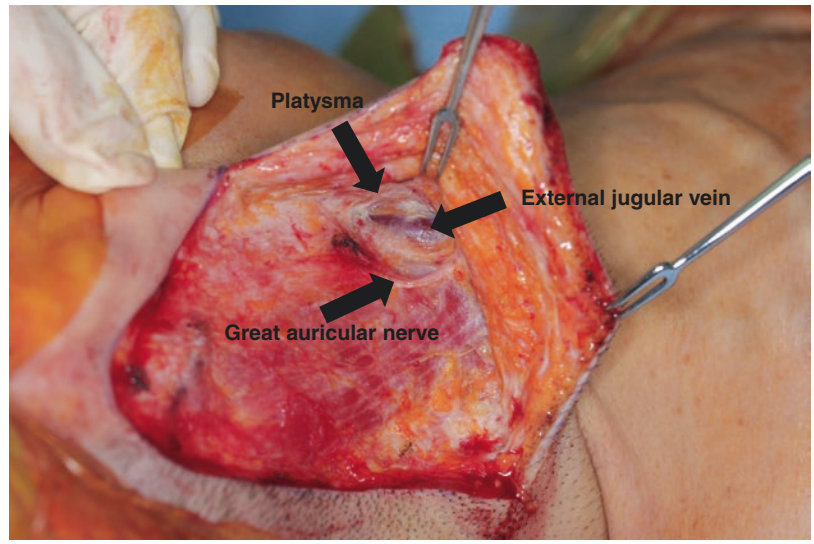

Fig. 12.2 A subplatysmal skin flap is elevated leaving the great auricular nerve and the external jugular vein on the SCM fascia (Operative photograph of right-sided approach)

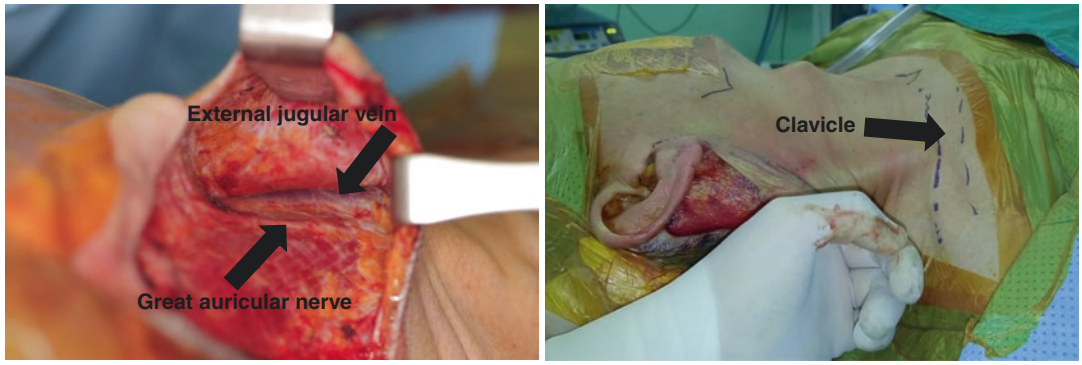

Fig. 12.3 The skin-subplatysmal flap is elevated so that it reaches the clavicle inferiorly, midline of the anterior neck medially, and the inferior border of the mandible superiorly. The posterior extent of the working space can be either made anterior or posterior to the SCM border depending on the type of robotic neck procedure

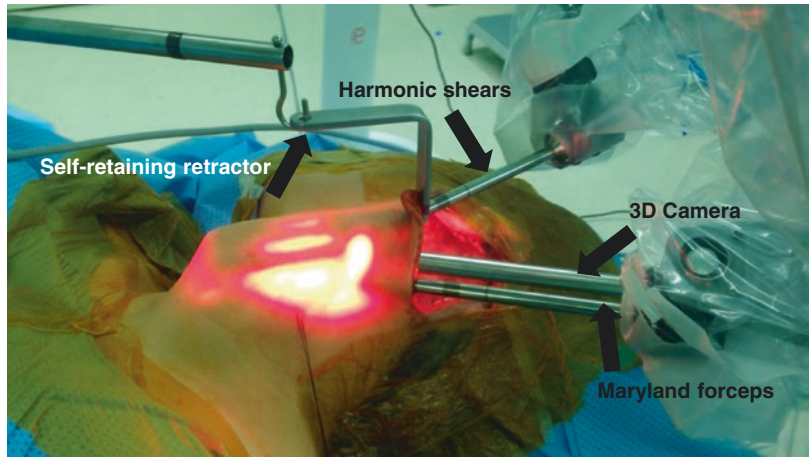

Fig. 12.4 After completion of working space creation and gross dissection, the robotic arms are docked to commence robotic dissection. A facedown 30° dual endoscope is placed at the center, and two robotic instrument arms each equipped with 5 mm Maryland forceps and 5 mm Harmonic curved shears are inserted at either side (Operative photograph of left-sided approach)

12.3 Surgical Technique

12.3.1 Robotic Surgery of Benign Neck Mass

Almost all cases of benign neck mass can be competently removed by the RA approach. Here, three commonly performed surgical procedures are addressed in detail.

12.3.1.1 Robot-Assisted Sistrunk's Operation (Fig. 12.5)

Following the docking of the robotic arms, the midline of the neck is recognized by dividing the fibroadipose tissue at the anterior neck using a 5 mm Maryland forceps and a 5 mm spatula monopolar cautery (Figs. 12.6 and 12.7).

Further mobilization of the contralateral side of the hyoid bone is done and resected also with the bone cutter. The thyroglossal duct should be traced further beyond the hyoid bone, and eventually the main mass together with the resected hyoid bone is removed en bloc through the RA port.

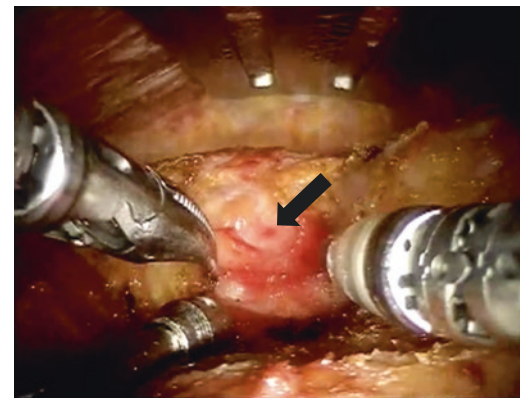

Fig. 12.5 After subplatysmal skin flap elevation through the RA incision and establishment of the working space, the robotic arms are introduced. Contour of the thyroglossal duct cyst lesion (*arrow*) can be readily visualized beneath the strap muscles (Operative photograph of left-sided approach)

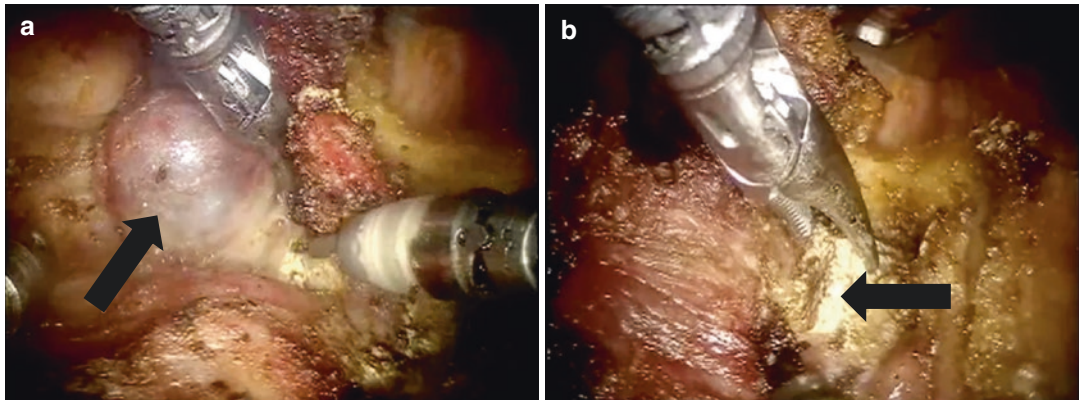

Fig. 12.6 The cystic lesion is carefully dissected and mobilized, and the contour of the hyoid bone is identified and skeletonized. (**a**) *Arrow*: thyroglossal duct cyst. (**b**) *Arrow*: ipsilateral hyoid bone (Operative photograph of left-sided approach)

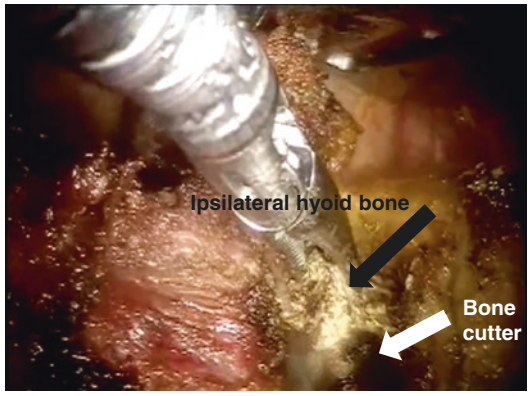

Fig. 12.7 Once the ipsilateral side of the hyoid bone is sufficiently mobilized, a conventional bone cutter is directly inserted through the RA port by the patient-side assistant, and the bone is cut

12.3.1.2 Robot-Assisted Neurogenic Tumor Excision

The subplatysmal skin flap is elevated, and sufficient area of working space is created before the robotic docking. Generally, for the removal of neurogenic tumors a Metzenbaum scissors (PK™ Dissecting Forceps) is used for the enucleation of the tumor (Fig. 12.8).

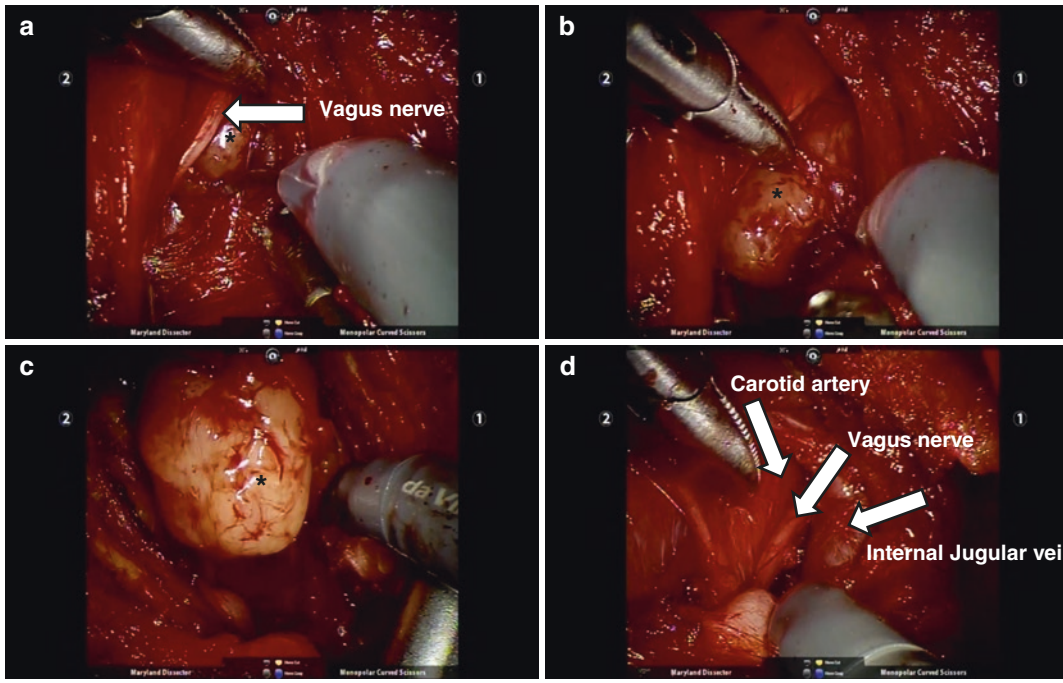

Fig. 12.8 Removal of vagal schwannoma. (Right-sided approach). (**a**) The neurogenic tumor is usually located in close proximity to the carotid sheath so dissection must be cautiously done when exposing the tumor. Special attention must be paid to prevent any injuries to other nerves around the carotid sheath. (**b**, **c**) Using the dissecting forceps, the true capsule of the neurogenic tumor (*asterisk*) is revealed, and the tumor is enucleated to minimize postoperative neural damage. (**d**) Post-removal surgical view with clear visualization of vital structures of the carotid sheath

12.3.1.3 Robot-Assisted Submandibular Gland Excision

After creating a sufficient area of working space, a self-retaining retractor is placed to maintain the height for robotic arms docking (Figs. 12.9 and 12.10).

Further subcapsular dissection is performed around the superior border of the SMG to proceed the dissection to the anterior portion of the gland (Fig. 12.11).

Care must be taken not to violate the tumor itself during the dissection. Interaction of the robotic surgeon with the patient-side assistant surgeon is important. The traction and countertraction manipulation should be well coordinated by appropriate handling of the Yankauer suction tip or endoscopic dissector held by the assistant. This surgical technique of robot-assisted submandibular gland resection is considered a key, fundamental procedure for robot-assisted neck dissection (RAND), so it is recommended for a beginning surgeon to experience a sufficient number of these procedures before attempting RAND.

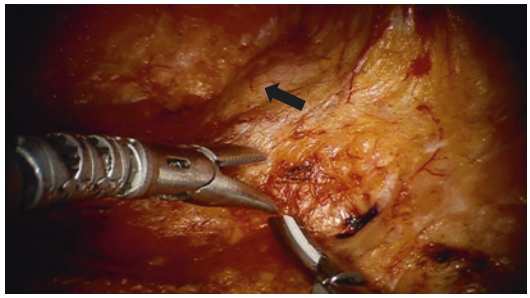

Fig. 12.9 Once the robotic arms are all introduced, the contour of the submandibular gland (*arrow*) can be clearly delineated from the surgeon's console (Left-sided approach)

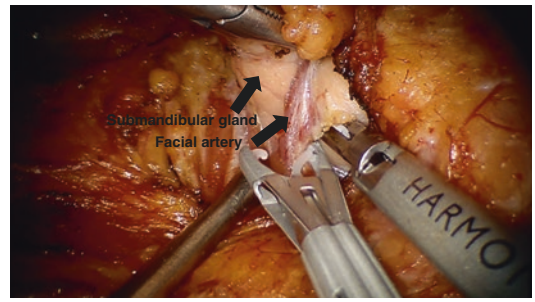

Fig. 12.10 The robotic dissection is commenced at the lower border of the submandibular gland. Subcapsular dissection is continued with Harmonic curved shears or monopolar cautery until the proximal portion of the facial artery is identified. The vessel can be ligated either by Harmonic curved shears or Hem-o-lok ligation system (Teleflex Inc., Research Triangle Park, NC) (Left-sided approach)

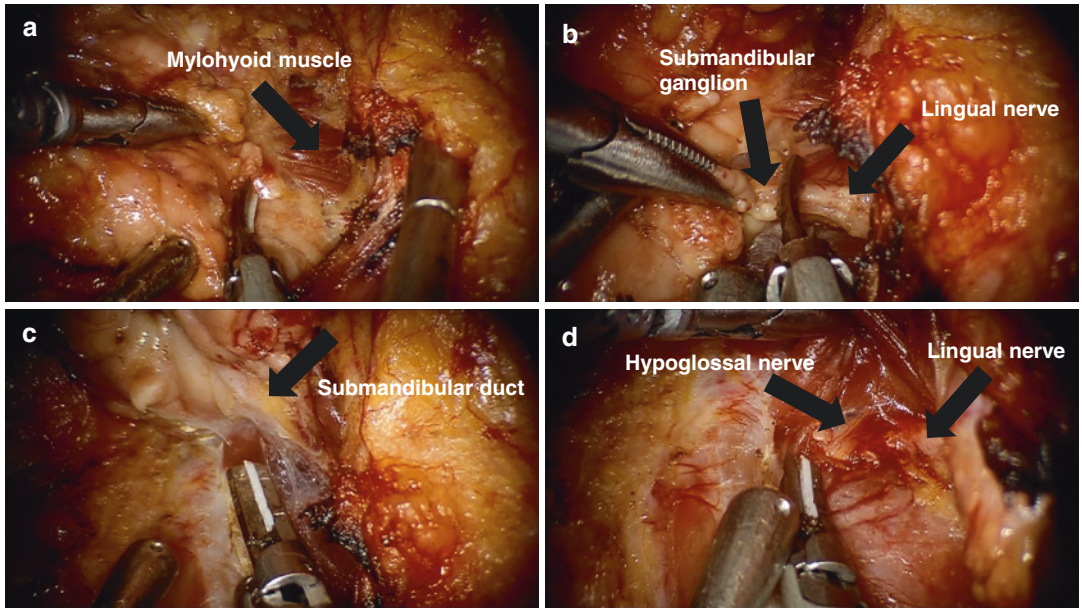

Fig. 12.11 (**a**) The specimen is retracted posteriorly to identify the mylohyoid muscle located at the anterior aspect of the submandibular gland. (**b**, **c**) The posterior border of the mylohyoid muscle is dissected, and posterior retraction of the submandibular gland is maintained to reveal the Wharton's duct and submandibular ganglion. These anatomical structures are ligated after confirming the intact course of the lingual nerve and hypoglossal nerve. (**d**) Surgical view after submandibular gland removal showing intact lingual nerve and hypoglossal nerve (Left-sided approach)

12.3.2 Robot-Assisted Neck Dissection

The procedure of RAND can be equally applied to both cN0 or cN+ necks in head and neck cancer. For the RAND in cN+ necks, main vital neurovascular anatomical structures such as spinal accessory nerve, internal jugular vein, and sternocleidomastoid muscle must be preserved considering that the main purpose of RAND is to minimize postoperative morbidities. Therefore, in any cases where this is not feasible, the authors recommend conventional open neck dissection rather than RAND. Careful, prudent selection of patients for therapeutic RAND must therefore be carried out beforehand, with close examinations of preoperative imagings.

Here, the RAND procedure is specified in detail with emphasis on two distinct operations: selective neck dissection (levels I–III) and comprehensive neck dissection (levels I–V). Other types of neck dissection can be performed by selective modifications of these two procedures.

12.3.2.1 Selective Neck Dissection (Levels I–III)

Pre-robotic Procedure

Certain amount of dissection is conducted under naked eye beforehand, prior to robotic dissection. Generally, the dissection is followed according to the conventional neck dissection procedure (Figs. 12.12, 12.13, and 12.14).

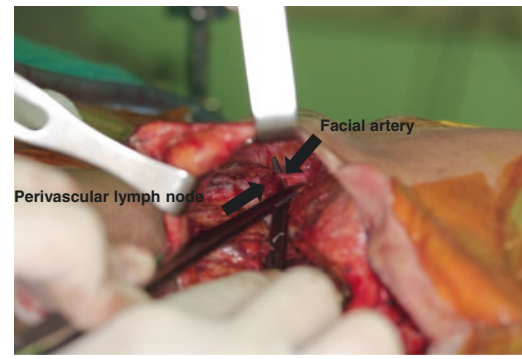

Fig. 12.12 First, level Ib dissection is performed. The marginal branch of the facial nerve is identified by visualizing the facial vessels around the mandibular notch. The nerve is handled with extreme care while dissection of the perifacial lymph nodes is done. After ligation of facial artery and vein, the lymphoadipose tissues inferior to the parotid tail are dissected (Left-sided approach)

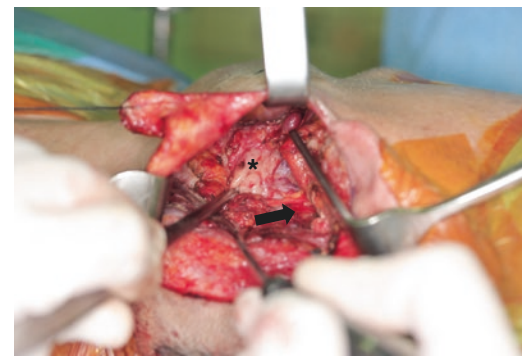

Fig. 12.13 Dissection is continued to the inferior border of submandibular gland (*asterisk*), revealing the posterior belly of digastric muscle (*arrow*) below (Left-sided approach)

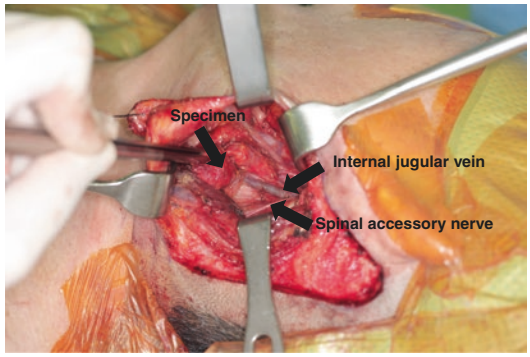

Fig. 12.14 Dissection along the anterior border of sternocleidomastoid muscle leads to exposure of the internal jugular vein. The spinal accessory nerve is then identified where it crosses the internal jugular vein and is sequentially skeletonized, to remove the fibrofatty tissues of level IIb. Next levels IIa and III are continuously dissected toward the carotid sheath. Here, the specimen can be either removed or pushed aside to continue the robotic dissection (*Left*-sided approach)

Robotic Dissection (Figs. 12.15, 12.16, 12.17, and 12.18)

Next the direction of dissection is turned to levels II and III, around the carotid sheath. The inferior extent of the dissection is the omohyoid muscle, and the medial extent is the midline strap muscles. The specimen is then removed en bloc.

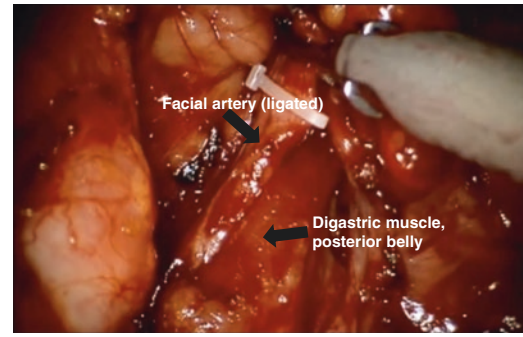

Fig. 12.15 The robotic dissection is commenced at level I. After recognizing the posterior belly of the digastric muscle, the previously dissected proximal facial artery at the posterior portion of the submandibular gland is ligated with Harmonic curved shears or Hem-o-lok ligation system (Right-sided approach)

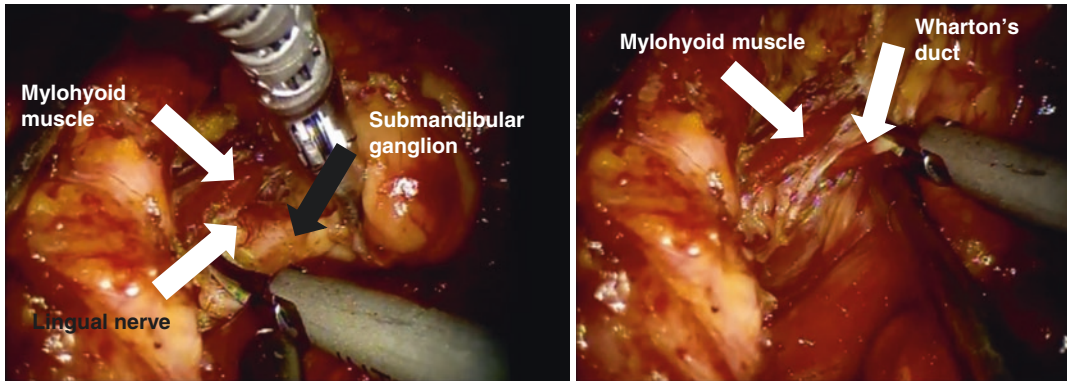

Fig. 12.16 Dissection is then continued anteriorly to identify the mylohyoid muscle and the underlying submandibular ganglion and Wharton's duct which are consequently sealed off (Right-sided approach)

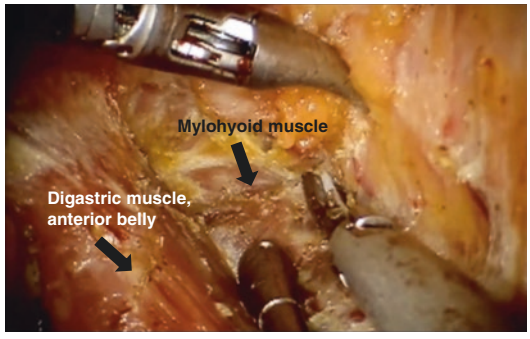

Fig. 12.17 The specimen is then retracted posteriorly, and the dissection moves on to level Ia between the anterior bellies of right and left digastric muscles (Right-sided approach)

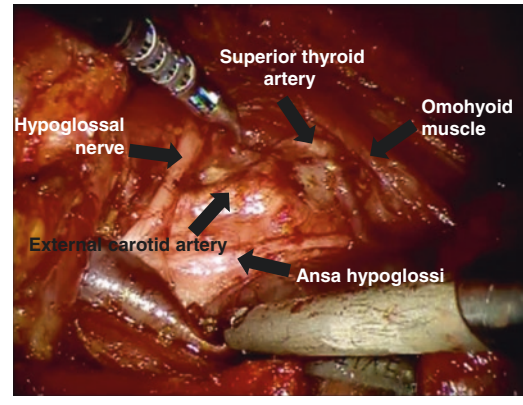

Fig. 12.18 Postsurgical view. The resulting postsurgical field is irrigated and thoroughly checked for any bleeding points, and a closed suction drain is inserted posterior to the hairline, and then the skin is closed with simple interrupted sutures (Right-sided approach)

12.3.2.2 Modified Radical Neck Dissection (Levels I–V or II–V)

Pre-robotic Procedure

The RA incision and skin-subplatysmal flap is elevated similarly; however, when creating the working space, the flap should be sufficiently elevated beyond the posterior border of the sternocleidomastoid muscle to meet the trapezius muscle so that levels IV and V are properly addressed. When level I is omitted in the procedure, the skin flap does not have to be as high up as to the inferior margin of the mandible. It would only increase the chance of direct/indirect marginal mandibular nerve injury.

After placing the self-retaining retractor, gross dissection is initiated at the appropriate level according to the type of neck dissection (levels I–V or II–V)

For the comprehensive dissection of level I–V, the dissection starts at level Ib by identifying the marginal branch of facial nerve as described previously for the selective neck dissection of levels I–III. When conducting the neck dissection of levels II–V, the dissection is commenced at level II with identification of the inferior border of the submandibular gland.

Dividing the fascia at the inferior border of submandibular gland, the dissection is proceeded posteriorly to release the parotid tail. Likewise, the posterior belly of digastric muscle is identified below the submandibular gland, and it is followed posteriorly to locate the internal jugular vein. Next, the spinal accessory nerve is identified, and the fascia at the anterior border of the sternocleidomastoid muscle is opened up. The dissection is continued medially visualizing the carotid sheath and as far inferior as possible to level IV (Figs. 12.19 and 12.20).

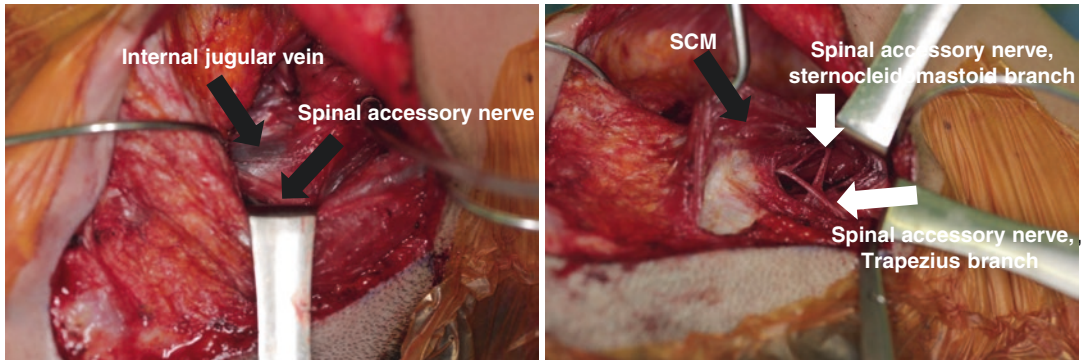

Fig. 12.19 The course of spinal accessory nerve is traced and skeletonized from its exit near the skull base to its entry at the trapezius muscle (Right-sided approach)

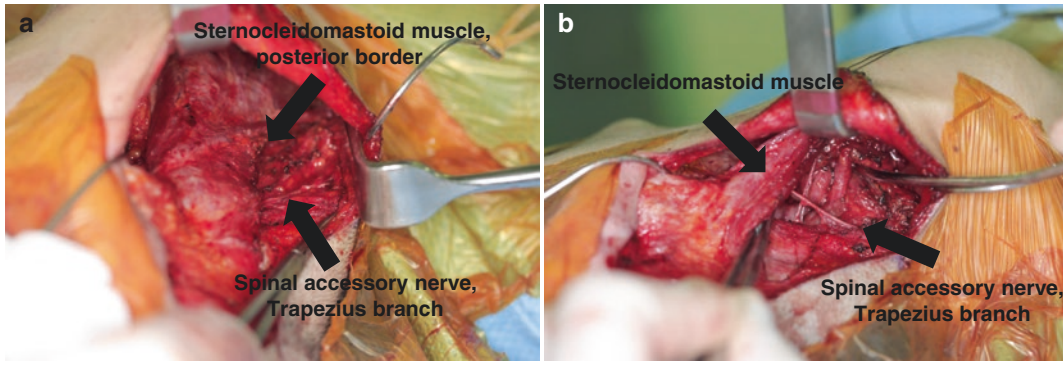

Fig. 12.20 (**a**) The next step is releasing the fascia at the posterior border of the sternocleidomastoid muscle so that the muscle can be lifted upward with a retractor. The lymph nodes tissue covering levels IIb and Va is collectively dissected and driven toward the lateral aspect of the carotid sheath at levels IIa and upper III. Here, some portion of levels IIa and III are further dissected under direct vision. (**b**) Next, the self-retaining retractor is readjusted so that the sternocleidomastoid muscle is elevated and maintained together with the skin flap. Before the robotic docking, the dissected specimen is usually taken out to obtain an optimal surgical view from the robotic console (Right-sided approach)

Robotic Dissection (Figs. 12.21, 12.22, 12.23, and 12.24)

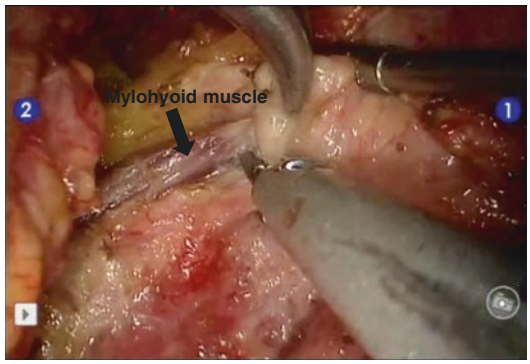

Fig. 12.21 If level I dissection is included in the operation, the robotic arms are aligned so that they maintain a parallel axis to the inferior margin of the mandible. Level I dissection is carried out as previously described for the selective neck dissection of levels I–III (Right-sided approach)

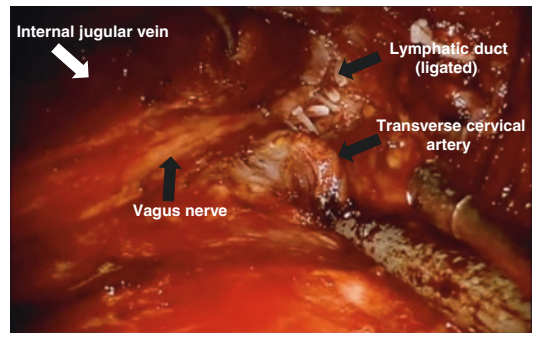

Fig. 12.23 When dissecting the area around the internal jugular vein near the clavicle, the lymphatic or thoracic duct should be routinely checked and ligated using hemoclips or Hem-o-lok ligation system even it has not been violated, to prevent the possibility of future chyle leakage (Right-sided approach)

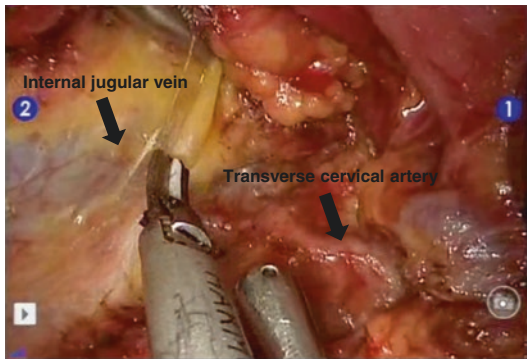

Fig. 12.22 The transverse cervical artery and the phrenic nerve running underneath this vessel can be identified during the dissection of levels Vb and inferior IV. The dissection is continued medially until it meets the carotid sheath (*Right*-sided approach)

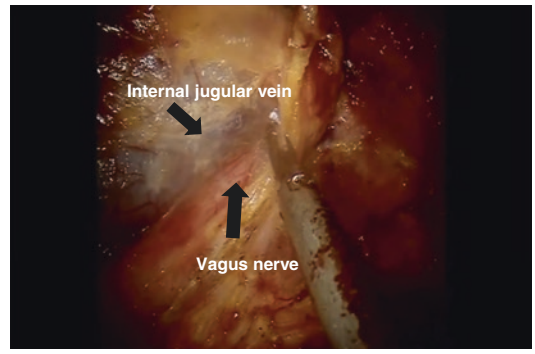

Fig. 12.24 The dissection is directed superiorly, identifying the vagus nerve, carotid artery, and internal jugular vein and carefully preserving the structures. During carotid sheath dissection, appropriate maneuvers must be provided by the assistant surgeon to maintain an appropriate traction-counter traction force balance to aid the dissection procedure. The branches of internal jugular vein are ligated with harmonic curved shears or Hem-o-lok ligation system

To begin levels IV and V dissection, the robotic arms should be repositioned so that the axis is in a cephalocaudal direction, facing toward the clavicle. The previously dissected tissue of level Va is grasped with the robot, and dissection is conducted superiorly to inferiorly. As the level of dissection reaches level Vb, the specimen is retracted medially, and the dissection continues to meet the omohyoid muscle which is consequently cut.

After completion of the dissection, the final neck specimen is delivered through the RA port. The postsurgical bed is irrigated and bleeding control done, before placing a closed suction drain. The surgical wound is then sutured with simple interrupted sutures.

12.4 Surgical Considerations

Generally, the Harmonic curved shears-mounted robotic arm is placed at the surgeon's dominant hand and the Maryland forceps at the nondominant hand. In terms of difficulty, there is no significant difference between a right-sided and a left-sided surgery; however, the dominant-sided surgery may be more comfortable to perform for the robotic surgeon.

12.5 Potential Postoperative Complications

Possible complications of this robotic RA surgery include:

- Nerve injury
  - Lingual nerve injury
  - Hypoglossal nerve injury
  - Marginal mandibular branch of facial nerve injury (mouth corner deviation)
  - Vagus nerve injury (vocal cord palsy)
  - Sympathetic nerve injury (Horner's syndrome)
  - Spinal accessory nerve injury (spinal accessory nerve syndrome)
  - Phrenic nerve injury
- Bleeding/hematoma
- Seroma
- Chyle leakage (lymphatic/thoracic duct injury)
- Wound infection, dehiscence
- Ischemia or necrosis of skin flap

The potential complications are similar to those from a conventional open neck operation. Mouth corner deviation may result from various degree of injury of the marginal branch of the facial nerve. The surgeon should pay special attention when dissecting around level I to avoid direct/indirect injury to the facial nerve. Main causes of indirect injury to the marginal mandibular nerve are thermal energy generated by surgical instruments and traction made by external retractors. Most indirect injuries of the facial nerve cause temporary mouth corner deviation which generally resolves within 2–3 months after the operation.

The surgical field from the RA port is relatively narrow, so there is a higher chance of major neurovascular structure injuries. A comprehensive knowledge and familiarizing the local surgical anatomy and a sufficient amount of surgical experience are prerequisites to minimize such complications.

Occasionally skin problems such as ischemic change or necrosis may occur at the RA skin flap. These consequences can be avoided by limiting the upper end of the flap to the level of the external auditory meatus and avoiding an acute angle of the skin curvature when designing the incision. Hair loss can occur along the skin incision within the hairline, but this can be minimized by beveling the incision at this portion.

12.6 Further Applications

Robot-assisted neck surgery via RA approach can be applied virtually to all surgeries for lesions located in the neck. Other benign neck mass such as parapharyngeal tumor, branchial cleft cyst, and lipoma can be removed, and thyroidectomy can also be performed via RA approach, with the

aid of the robotic system. Hypopharyngeal tumors can also be removed robotically by the RA approach after exposing the tumor via lateral pharyngotomy. Moreover, free flap reconstruction is feasible with the robot inserted from the RA port.

It is expected that this surgical technique will continuously evolve even more with the technological refinements regarding the robotic system. Already, the introduction of the upgraded da Vinci Xi system (Intuitive Surgical Inc., Sunnyvale, CA) has enabled inserting an extra robotic instrumental arm through the RA port, thereby minimizing the role of the assistant surgeon. Furthermore, unlike the former procedure, the robotic dissection can be now be conducted right after the working space creation, since an extra robotic arm will provide more comfortable dissection and sustained retraction. Most recently, there are expectations that there will emerge a multi-instrument-mounted, "single-port" robotic system which will take the robotic neck surgery to the next level. Not only would the RA robotic surgery be easier to learn and practice, but the surgical skill itself could be further refined by placing a smaller incision.

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