Robotic Thyroidectomy

Past, Future, and Current Perspectives

Emad Kandil, MD, MBA*, Abdallah S. Attia, MD,
Deena Hadedeya, MD, MHS, Areej Shihabi, MD, Ahmad Elnahla, MD

KEYWORDS

• Robotic thyroidectomy • Transaxillary • Transoral • Retroauricular • Facelift

KEY POINTS

- Remote access approaches (RAA) use the axillary approach, the axillary-bilateral breast approach, the bilateral axilla-breast approach, the retroauricular approach, and the transoral approach.
- The installation of the robotic system in surgery overcomes many limitations of the RAA.
- Benefits and the constraints of remote access approaches.

INTRODUCTION

Through the past decades, there was an immense revolution in the surgical approaches for thyroidectomy. In 1997, since Huscher[1] did the first minimally invasive thyroidectomy, this technique and remote access approach (RAA) have gained notoriety. After a year, Paolo Miccoli and colleagues[2] started the minimally invasive video-assisted thyroidectomy in 1998. However, many studies proved its feasibility and safety. It is still questionable whether it can replace the conventional open approach or not.

Remote access approaches (RAA) use the axillary approach, the anterior/breast approach, the axillary-bilateral breast approach, the bilateral axilla-breast approach, the retroauricular approach, and the transoral approach.[3] The introduction of the robotic system in surgery overcomes many limitations of the RAA. Lobe and colleagues[4] performed the first robotic thyroidectomy via a trans-axillary approach in 2005. Since that time, many surgeons have reported their experience with RAA for thyroid surgery. Chung and colleagues[5] published his experience with more than 5000 cases with a comparable rate of complications with the open conventional approach. Others and we reported the most substantial experience in the United States with the transaxillary approach.[6] Duke and colleagues[7] published the first most prominent data on consecutive patients undergoing robotic facelift thyroidectomy (RFT) in 5 North American

Department of Surgery, Tulane University, School of Medicine, New Orleans, LA 70112, USA
* Corresponding author.
E-mail address: ekandil@tulane.edu

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academic endocrine surgical practices that were compiled. The study showed that RFT could be offered to selected patients to avoid neck scare. This review details surgical approaches for robotic thyroidectomy: transaxillary, retro auricular, and transoral. In this article, we explain the benefits and the constraints of each approach and future directions of robotic thyroidectomy.

PATIENT SELECTION

Although there are various types of robotic thyroidectomy by far, transaxillary is the most commonly used approach. Moreover, the transoral approach is the most novel described approach. Surgeons must be aware of their skills and should have performed a high-volume of surgery before deciding on which method to use and put into consideration the patient's decision. The American Thyroid Association reported that remote access thyroidectomy might only be performed safely in high-volume centers. They have also highlighted and established strict guidelines for the patient's selection.[8] The indications for thyroidectomy should be the same as for standard surgery. Surgeons should review the following circumstances for patient selection. Factors relating to the patient that should ideally be considered in early experience include (1) lean body habitus (except for the facelift approach) and (2) the absence of excess body fat along the flap trajectory (except for the facelift approach). Factors relating to the thyroid pathology include (1) well-circumscribed nodule less than or equal to 3 cm 2) thyroid lobe less than 7 cm in the largest dimension and 3) underlying thyroid pathology with no evidence of thyroiditis on ultrasound. Factors relating to specific approaches include the fact that the distance between the axilla and the sternal notch should ideally be less than 15 to 17 cm for an axillary approach. Absolute contraindications include: 1) evidence of thyroid cancer with extrathyroidal extension or lymph node involvement; 2) Graves disease; 3) substernal extension; and 4) previous neck surgery; 5) evidence of preoperative recurrent laryngeal nerve palsy.[8,9]

SURGICAL TECHNIQUES

Both the transaxillary and retroauricular approaches are performed in a gasless fashion, whereas the transoral technique requires carbon dioxide (CO_2) gas insufflation. However, Young Min and colleagues[10] reported cases of successful gasless transoral approach and proved its safety and feasibility. Many recommend using intraoperative nerve monitoring (IONM) for robotic thyroidectomy cases.[11] The surgical techniques of these 3 approaches using the da Vinci robots are described later. Despite the chosen approach, there are 3 consistent steps to robotic thyroidectomy: (1) working space creation, (2) docking, and (3) console stages.

THE TRANSAXILLARY APPROACH

Working Space Formation

After general anesthesia is administered, the patient is in the supine position with a slight extension of the neck.[12–14] Neck extension is accomplished by using a large shoulder roll to provide appropriate field exposure.[13] The ipsilateral arm is then stretched and twisted cephalad, fully showing the axilla. It is vital to assess the extent of the patient's arm extension/abduction without implementing additional force to prevent avoidable overextension of the arm, which can lead to accidental brachial plexus injury. Intraoperative nerve monitoring via somatosensory evoked potential (SSEP) has been used to avoid the injury. Ulnar, median, and radial nerves of the arm ipsilateral to the surgical incision were individually stimulated at each nerve's respective location on the wrist. The contralateral arm positioned at the patient's side was stimulated at the median nerve as a positive control. The monitoring of SSEP was initiated preoperatively, recorded during patient positioning, and continued intraoperatively. A warning was relayed to the surgeon if IONM detected an amplitude decrease of greater than or equal to 50% and/or a greater than or equal to 10% increase in signal latency.[15] A 5- to 6-cm curved vertical line is formed just posterior to the anterior axillary fold. This arm is padded and secured, applying a tape. Once the ideal position is reached, the patient's arm, neck, and chest are prepped and draped, exposing the axilla, neck, and upper chest. The incision is created using a 15 blade, and the subcutaneous flap is raised using electrocautery. It is essential to maintain the fascia overlying the pectoralis major muscle to limit postoperative adhesions, which may lead to increased discomfort and pain over the chest area. Once the pectoralis major is exhibited, a careful dissection over the clavicle is performed until the sternocleidomastoid (SCM) muscle is revealed. It is vital to preserving the posterior triangle soft tissue structures to possible avoidable injury to the external jugular vein and an increased risk of postoperative hematoma. Once the SCM is exposed, the dissection proceeds by opening the avascular plane between the clavicular and sternal heads of the SCM. The surgeons must enter this avascular space correctly to avoid possible injury to the major vessels that are lying directly below the route of dissection. Strap muscles are then found. The dissection is then carefully proceeded directly underneath the strap muscles exposing the thyroid gland. The working space is considered to be safe and adequate if sufficient space is created, showing the superior pole of the thyroid and central neck. Once the dissection is completed, Chung retractor or an equivalent retractor is placed holding the subcutaneous flap, anterior SCM, and strap muscles upward to keep the working space exposed. In the case of total thyroidectomy, the contralateral lobe should be completely exposed, and the position of the retractor should be appropriately adjusted to allow safe resection of the contralateral lobe.

Docking Stage

Once the surgeon reaches adequate working space, the robot approaches toward the patient from the opposite side in preparation for the docking of the arms. For the transaxillary procedure, all 4 robotic arms are used. For the right-sided approach, the arm closest to the head of the patient provides the Maryland dissector, followed by the second arm carrying the 30-degree endoscope. On the arm beside the endoscope arm, the ProGrasp forceps is implanted. The arm closest to the patient's feet leads the Harmonic scalpel. The order is shifted when the procedure is approached via the left side. This docking method guarantees that the surgeon operates using the Harmonic scalpel using his right hand, likewise to the open procedures. The Maryland and ProGrasp forceps provide continuous countertraction for safe and precise dissection, following the same surgical concepts used in conventional open surgeries. It is crucial to keep an adequate distance between each robotic arm to avoid clashing between the instruments. The docking stage massively depends on the skills and expertise of the surgeon and his operative team. Even a small variation in the docking position can affect the effectiveness of the console stage, and this statement holds regardless of the robotic thyroidectomy approach.

Console Stage

Once the perfect docking of the robotic arms is accomplished, the surgeon may advance to the console stage. The superior pole is first dissected by determining the superior vessels. This first step is crucial to recognize the superior parathyroid gland and safely make sure to keep it. Once the superior pole is freed, then the attention is directed to the inferior pole. If the central neck dissection (CND) is required, then this is made en bloc before the inferior pole dissection. The recurrent laryngeal nerve (RLN) should be identified inferiorly and dissected superiorly toward Berry's ligament while dissecting the thyroid gland off of the neighboring structures. The isthmus is then divided, which concludes the hemithyroidectomy. The entire CND content and thyroid gland are taken out en bloc. Once the specimen is detached, careful examination of the surgical field is conducted for verifying of hemostasis.

THE RETROAURICULAR APPROACH

Working Space Creation

The patient is placed supine after intubation with general anesthesia with the head turned smoothly to the contralateral side from the approach, showing the posterior auricular sulcus with the posterior area of the neck facing the surgeon. The incision is drawn along the posterior auricular sulcus reaching over the mastoid and inferiorly parallel to the occipital hairline. The patient is prepped and draped, showing the incision line, neck, and the ipsilateral half of the face. Once the cut is made, the subcutaneous retroauricular flap is lifted anteriorly, exposing the parotid tail and the SCM. In our experience, we maintained the flap superficial to the platysma.[6] However, others maintained a subplatysmal flap.[15] Deep dissection beneath the strap muscles is made to identify the thyroid gland. A modified Chung retractor is inserted underneath the strap muscles.

Docking Stage

Once an adequate working space is secured, the robotic system is docked. If the working area allows, it is always preferable to use all 3 robotic divisions (30-degree endoscope with 3 instrument arms) to facilitate the surgery. If the working space is inadequate, the surgeon can still perform the surgery using only 2 instrument arms without the ProGrasp. Operating with 2 instrument arms rather than 3 is technically more challenging. The docking method is similar to the transaxillary approach, where the surgeon's hand controls the Maryland dissector and the right-hand controls the Harmonic scalpel.

Console Stage

The steps of the hemithyroidectomy via the retro auricular approach start with the identification and dissection of the superior pole. The superior pole is smoothly retracted superiorly, and the superior pole vessels are carefully ligated one vessel at a time. During these steps, the surgeon must distinguish the superior parathyroid gland and preserve it. Accurate and gentle dissection is advised to minimize the chance of thermic damage to the parathyroid gland. Once the superior pole is liberated, and the cricothyroid muscle is recognized, the isthmusectomy is then performed, which will assist in the recognition and dissection of the RLN. The nerve is distinguished in the tracheoesophageal groove near the cricothyroid joint, where the nerve accesses the larynx. The IONM probe can be used to confirm the RLN. Once the nerve is correctly recognized and verified via IONM, the rest of the thyroid gland is dissected off of its adjacent soft tissue while keeping the RLN uninjured along its course. With the dissection of the inferior pole, the operation is achieved.

THE TRANSORAL APPROACH

Working Space Creation

After the patient received general anesthesia, the patient's neck should be placed in a slight extension. Three incisions are performed in the gingival-buccal sulcus: one in the midline, about 2 cm up the frenulum labii inferioris and 2 laterally close to the angle of the mouth. The midline incision is marked first. A submental subplatysmal opening is formed to create a tunnel toward the edge of the mandible. Blunt dissection is conducted to raise the platysma of the strap muscles all the way down toward the suprasternal notch. This blunt dissection is aided via injections of saline mixed with epinephrine into the subplatysmal layer. Once a sufficient flap is formed, the endoscope (30 degrees, down-facing) cannula is implanted. CO_2 insufflation (8–10 L/min) is initiated and maintained via the central port. Alike blunt dissection is also made from the 2 lateral incision sites, allowing the introduction of the instrument cannulae into the subplatysmal working area. Vicryl stitches are then applied to help retain the subplatysmal flap superiorly to form a larger working area.

Docking Stage

Once the working space creation is complete, the robotic system is stationed. The cannulae are implanted into the robotic arms, beginning with the central cannula to ensure the position of the endoscope. A Harmonic scalpel and Maryland dissector are embedded into the right and left ports, respectively.

Console Stage

Dissection in the midline raphe is conducted to separate the strap muscles. The strap muscles are cut off the thyroid gland, revealing the lobe of importance. The pyramidal lobe is cut off the thyroid cartilage, followed by isthmusectomy is delivered. Once the thyroid lobe is released from the trachea medially, the superior pole is marked. Careful dissection of the superior lobe is made ligating one vessel at a time. The superior parathyroid gland is distinguished and protected. The thyroid lobe is retracted inferiorly to aid the identification of the RLN at its entry point into the larynx. Once the RLN is identified and carefully protected, Berry's ligament is identified. The dissection is then carried out, inferiorly protecting the inferior parathyroid gland. Once the inferior lobe is liberated off of its surrounding soft tissue, hemithyroidectomy is complete.

ADVANTAGES AND DISADVANTAGES

In this review, the authors discuss different types of remote access thyroidectomy; each of them has its advantages and disadvantages, given all the steps to perform those types of thyroidectomy. Knowing the benefits and limitations of each approach will help the surgeon make the best recommendations for each patient.

The transaxillary approach was invented primarily by doing 2 separate incisions, one in the axillary crease and the other on the anterior chest. Recently, just using one incision through the axillary crease, surgeons can perform thyroidectomy safely. The main advantages of the transaxillary approach are to ease the console stage, facilitate the detection of the recurrent laryngeal nerve, more access to do central and lateral neck dissection, and well-established literature showing its safety and feasibility. Not only that, but it is also the only approach that does not disrupt the area between the superficial neck muscles, which in turn aims for more favorable swallowing outcomes compared with other plans.[12,16–18] One of the main disadvantages of the transaxillary method is the possible risk of brachial plexus injury,[19–22] which can be avoided with proper arm positioning and extrapadded support. In our early experience, 137 robotic transaxillary surgeries using SSEP monitoring were performed on 123 patients. Seven patients (5.1%) developed significant changes, with an average SSEP amplitude reduction of 73% $\pm$ 12% recorded at the signals' nadir. Immediate arm repositioning resulted in the recovery of signals and complete return to baseline parameters in 14.3 $\pm$ 9.2 minutes.[23] Also, others reported no brachial plexus injury with a high-volume surgeon,[1] high volume hemorrhage, and damage to the esophagus are other reported complications however these events are rare and deceased when surgeons became used to the lateral approach.[6,24,25] But these complications are rare and deceased when the surgeons became used to the lateral approach. We routinely perform monitoring for the median and ulnar nerves using somatosensory evoked potentials (SSEP) (Biotronic, Ann Arbor, MI, USA) to avoid neuropraxia. However, many other robotic surgeons did not use SSEP and were able to prevent this severe complication by careful positioning of the arm. Patients could experience anterior chest paresthesia over the clavicular area with nonavoided injury to the sensory nerves of the cervical plexus chain. These nerves are encountered as the subplatysmal flap is elevated off the clavicle toward the SCM and needs to be sacrificed to create a safe working space. For most of the cases, this paresthesia is temporary, but it was reported as permanent in rare tiny cases. Therefore, this complication should be discussed with the patient while obtaining informed consent.[26]

Terris first described the advantage of a retroauricular approach over the transaxillary one,[19,27] contemplating that the significantly reduced field of dissection in the transaxillary method, when compared with the retroauricular approach, is associated with faster recovery and decreased postoperative distress.[27] He also describes the retroauricular technique to be more comfortable than the transaxillary method when working on obese patients.[27] This statement seems to be verified by the American Thyroid Association, as its last statement on robotic surgery states that remote-access surgery should be carried out in patients with normal body weight without extra body fat except for the retroauricular approach.[8] The retroauricular approach also reduced the risk of damage to the vessels, the esophagus, or the anterior chest nerves because these structures are hard to be dodged during the working space creation. Some disadvantages are integral to this approach: injury to greater auricular and marginal mandibular nerves.[24,25,27] These adverse events are usually temporary and fully resolve within a few months following surgery. But these possible adverse events should be discussed in detail for informed consent before surgery.

The transoral approach described by Kim and colleagues can cause a mental nerve injury as they come out from the mental foramina radiating its branches to the lip which has been by overcame by adjusting the sites of incisions.[28] This has since been overcome by adjusting the sites of incisions to avoid damage to the mental nerves as they come out from the mental foramina radiating its branches to the lip. This approach's main benefits are the completely unseen intraoral scars, excellent access, display of the bilateral thyroid lobes for total thyroidectomy, and a reported lower adverse events profile compared with other remote-access procedures. The transoral technique offers the unique superiority of reaching the thyroid gland from a natural opening, and its midline access provides excellent exposure to the whole thyroid gland, making this the most harmless approach to perform a total thyroidectomy when compared with other approaches.

The main limitations of this technique are the necessity for postoperative antibiotics and incapability to do lateral neck dissections. There were no reports of postoperative infections following transoral robotic thyroidectomy; however, postoperative antibiotics are supplied for all patients due to the possible risk of infection. The transoral thyroidectomy is not acknowledged as a clean procedure, unlike its traditional open equivalent. Recent studies on transoral approaches reported shorter hospital stay than bilateral axillo-breast approach robotic thyroidectomy.[29] Another potential downside of this approach is the incapability to control substantial hemorrhage through the intraoral incision in case of accidental great vessel injury. If such hemorrhage were to happen, then an anterior neck incision would be performed to control the bleeding. The most significant weakness of the transoral approach is the incapability to do lateral neck dissections. This challenge may never be overcome, given the anatomic limitations, and may indicate the usage of 2 approaches when performing neck dissections on patients with extended lateral neck disease. Lateral neck dissections are performed via remote-access approaches (RAA) frequently around the world, except the United States. In a study by Adam and colleagues[30] they reported there were no differences in hospital length of stay between robotic and conventional thyroidectomy groups even when the patient underwent neck dissection. Also, there was a nonsignificant trend toward a higher odds of positive surgical margins with robotic thyroidectomy. However, according to the American Thyroid Association statements, the presence of lateral neck disease is currently a contraindication to remote-access thyroid,[10] yet the transoral approach is vital for the surgeons to consider it while operating on obese patients, which is essential for the population of North America.[31]

All RAA shared one disadvantage, which is the high cost in comparison to the conventional transcervical approach. Cabot and colleagues[29] reported that the transaxillary robotic thyroidectomy approach was compared based on medical costs in the United States. A higher total cost for the transaxillary approaches was reported compared with the conventional technique ($13,087 vs $9028).[32] Broome and colleagues[33] mentioned the increase in cost as $3127 as higher than the conventional approach. Equivalence in cost for both procedures was noted, once the total operative time was decreased in the robotic approach to 111 minutes.[29] Although the cost is higher with RAA, it is of great value for patients who are motivated to avoid a visible neck scar. Multiple studies showed that cosmesis is a primary concern, especially for women; neck scars can cause disfigurement and significant stress, which would affect the patients psychologically and may impair their quality of life.[34–36]

SUMMARY

RAA is safe for a specific type of patient. It should be performed by experienced specialized surgeons in centers with high patients' volume. Yet, it did not completely replace the conventional approach, due to a high degree of training that is required before practice, high expenses that should be paid to perform a single operation, and the highly integrated teamwork that should be considered. Furthermore, studies and investigation should be considered regarding RAA, especially after proving its efficacy in reducing the risk of complications with an expert surgeon.

DISCLOSURE

The authors have nothing to disclose.

CLINICS CARE POINTS

- Offer remote access approach to eligible patients only.
- Remote access approach should be only performed by high-volume, well trained surgeons.
- Adequate training should be provided ahead of initiating their practice

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