Review Article

Feasibility and outcomes of remote-access endoscopic and robotic lateral neck dissection for thyroid cancer: a scoping review

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Background: Remote-access endoscopic and robotic thyroid surgery has progressively evolved over the decades to minimize visible neck scarring. Various approaches, including axillary, anterior chest, breast, postauricular, and transoral routes, have been developed, extending their application to lateral neck dissection (LND) in thyroid cancer. This study aims to comprehensively review and synthesize recent literature on remote-access endoscopic and robotic techniques for LND, with a focus on outcomes, advantages, and limitations.

Methods: A systematic literature review was conducted using PubMed and Cochrane Library databases. Search terms included "lateral neck dissection", "thyroid cancer", "remote-access", "robotic", "endoscopic", and "video-assisted". Eligible studies were analyzed to provide an in-depth overview of current techniques, addressing the following aspects: (I) incision location; (II) surgical procedures; (III) complications and surgical outcomes; and (IV) advantages and limitations of each approach.

Results: Various remote-access techniques for LND were identified, including gasless infraclavicular, breast-chest, gasless transaxillary, bilateral axillo-breast, gasless retroauricular, transoral, and combined approaches. Outcomes, including the number of removed lateral lymph nodes, complication rates, and recurrence rates, were comparable across remote-access approaches. The extent of dissection achieved with these techniques was equivalent to conventional approaches for levels IIa, III, IV, and V, except for the transoral approach, which was generally limited to levels III and IV. Postoperative cosmetic outcomes were significantly superior with remote-access techniques.

Conclusions: Remote-access approaches for thyroidectomy combined with LND are both feasible and safe, achieving complete resection of targeted neck levels with excellent surgical and cosmetic outcomes. The unique advantages and limitations of each method underscore the importance of careful patient selection to optimize clinical benefits.

Keywords: Thyroid cancer; lateral neck dissection (LND); remote access; endoscopic surgery; robotic surger

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Introduction

Thyroid cancer, particularly papillary thyroid carcinoma (PTC), has demonstrated an increasing incidence, now constituting over 90% of all thyroid malignancies (1). While the prognosis for PTC is generally favorable, lymph node metastases are a common occurrence, with clinical metastases present in approximately 30% of cases at diagnosis and micrometastases identified in up to 80% (2). According to the 2015 guidelines issued by the American Thyroid Association (ATA) and the National Comprehensive Cancer Network (NCCN), the standard treatment for PTC patients with lateral lymph node metastases includes total thyroidectomy accompanied by central neck dissection (CND) and lateral neck dissection (LND) (3,4).

Despite these established recommendations, the optimal extent of LND remains a subject of ongoing debate. Lateral lymph node metastasis in PTC follows a predictable pattern, typically originating in the central compartment before spreading to the lateral neck compartments. Within the lateral neck, levels III and IV are most frequently involved, followed by levels II and V (5-8). Notably, certain cases of PTC, particularly those involving tumors in the upper pole of the thyroid, exhibit skip metastases, bypassing the central compartment (6). As a result, current consensus guidelines advocate for total thyroidectomy with CND and comprehensive LND, encompassing at minimum levels IIa, III, and IV, in patients with lateral cervical lymph node metastases (3,4,8).

Traditional transcervical LND approaches are associated with the unavoidable consequence of prominent neck scarring, often in the form of a long collar or L-shaped incision, which significantly impacts patients' aesthetic outcomes (9). In response to the increasing demand for improved cosmetic results and the avoidance of visible neck scars, remote-access endoscopic and robotic LND techniques have been developed, particularly in Asian countries (10). Preliminary evidence suggests that these approaches are safe, yielding surgical and oncological outcomes comparable to those of conventional techniques while offering superior cosmetic benefits (10). Nevertheless, the feasibility and efficacy of remote-access LND procedures require further investigation to establish their definitive role in clinical practice. This review aims to evaluate the role and efficacy of remote-access endoscopic and robotic LND techniques. It focuses on key aspects of these approaches, including technical execution, indications, contraindications, surgical and oncological outcomes, advantages, and limitations. The study specifically excludes LND performed via minimally invasive video-assisted approaches (MIVAT) with small cervical incisions to maintain a focus on remote-access methods. We present this article in accordance with the PRISMA-ScR reporting checklist (available at https://gs.amegroups.com/article/view/10.21037/gs-2024-535/rc).

Highlight box

Key findings

- The number of removed lateral lymph nodes, complication rates, and recurrence rates do not differ significantly among the various remote-access lateral neck dissection (LND) approaches.

What is known and what is new?

- The gasless infraclavicular, breast-chest, gasless transaxillary, bilateral axillo-breast, gasless retroauricular, transoral, and combined approaches have been employed for remote-access LND.
- The extent of LND achieved using remote-access approaches is comparable to the conventional approach, encompassing levels IIa, III, IV, and V, except for the transoral approach, which is typically limited to levels III and IV.

What is the implication, and what should change now?

- Remote-access robotic and endoscopic LND is both feasible and safe. It allows for complete resection of targeted neck levels, achieving favorable surgical outcomes and excellent postoperative cosmetic results.

Methods

A comprehensive literature review was conducted in October 2024 using the PubMed and Cochrane Library databases. Search parameters included the terms "thyroid cancer", "lateral neck dissection", "remote access", "robotic", "endoscopic", and "video-assisted", with results limited to English-language publications. Duplicated records and non-human research were excluded. Subsequently, reviews and videos were also excluded. Furthermore, case reports and studies with small sample sizes were omitted unless they were deemed uniquely significant. For studies with overlapping patient cohorts, the analysis prioritized those with the highest methodological quality and largest sample sizes. Ultimately, the analysis included 33 articles, including 31 retrospective studies, one of which consists of two approaches and two case reports (*Figure 1*). These comprised two studies on the infraclavicular approach, six on the breast-chest approach, eight on the transaxillary approach, six on the bilateral

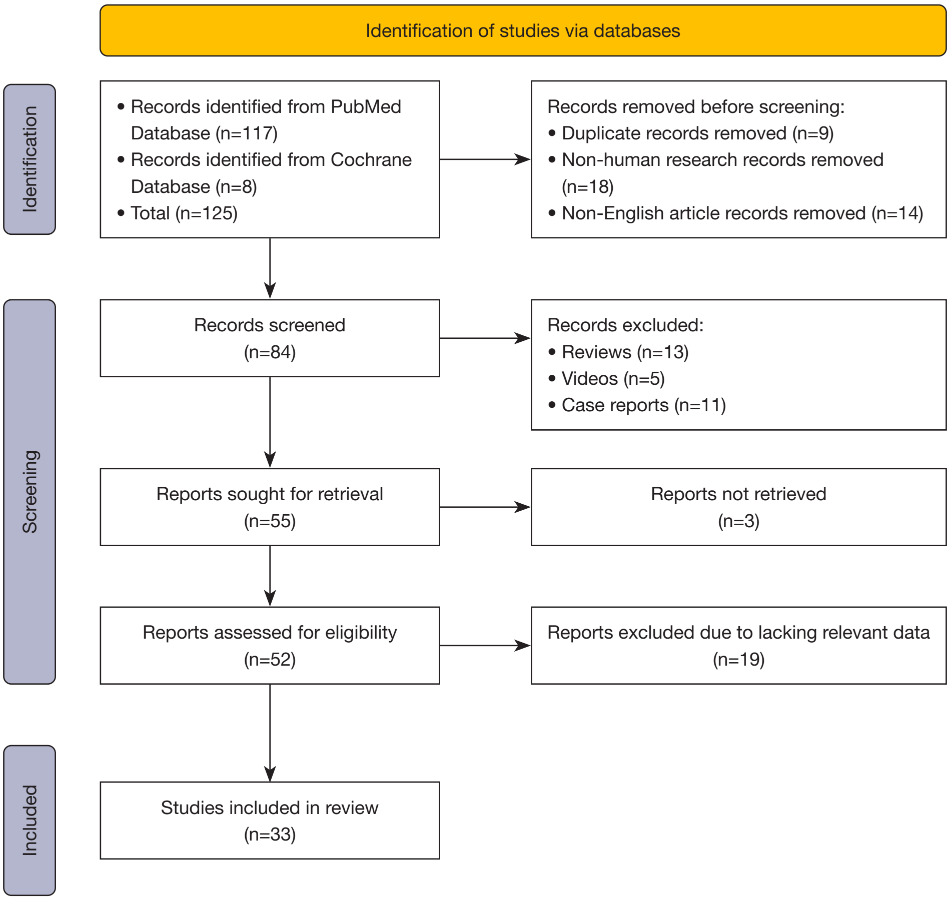

Figure 1 The PRISMA flow diagram of review.

axillo-breast approach (BABA), two on the retroauricular approach, four on the transoral vestibular approach, and six utilizing combined approaches.

Surgical procedural details and outcomes were meticulously extracted from each study. Variables analyzed included sample size, incision design, methods for maintaining the working space, operative time, extent of LND, lateral neck lymph node yield, surgical complications, follow-up duration, and recurrence rates and locations. Postoperative hospital stay duration was excluded from the analysis, as it is heavily influenced by country-specific insurance policies and does not reliably reflect recovery rates.

Results

Classification of remote-access LND

The classification of remote-access endoscopic and robotic thyroidectomy with LND was based on the site of remote incision, use of surgical robotics or endoscopy, and the application of CO_2 insufflation versus gasless techniques (11). Remote-access LND has been performed using infraclavicular, breast-chest, BABA, transaxillary, retroauricular, and transoral approaches (10).

The robotic technique was predominantly utilized for the transaxillary, BABA, and retroauricular approaches, while the endoscopic technique was primarily employed for the infraclavicular and breast-chest approaches. The transoral approach was performed using both endoscopic and robotic methods.

Additionally, the infraclavicular, transaxillary, and retroauricular approaches were performed using gasless methods, whereas the BABA and transoral approaches employed CO_2 insufflation. The endoscopic breast-chest approach was performed using either gasless or CO_2 insufflation techniques.

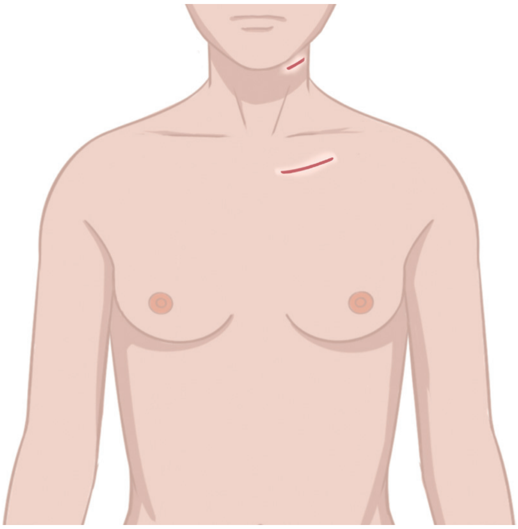

Figure 2 Endoscopic gasless infraclavicular approach.

The endoscopic procedure offers several advantages, including lower cost, ease of use, familiarity with laparoscopic systems and instruments, and potential reductions in operative time (11). Robotic procedures provide significant benefits, such as a three-dimensional magnified view, fine motion scaling, tremor filtration, advanced instrumentation with enhanced freedom of motion, and improved surgical education opportunities. Furthermore, the ability to use three robotic instruments simultaneously is particularly advantageous for achieving countertraction, facilitating dissection, and improving surgical dexterity and ergonomics during robotic procedures (11).

Indications and contraindications of remote-access LND

The indications for remote-access thyroidectomy and LND are broadly consistent across various surgical approaches. These techniques are primarily appropriate for patients with small PTC exhibiting limited lateral neck lymph node metastases who seek scarless neck surgery. In the transoral approach, the size of the primary tumor or thyroid gland can influence surgical eligibility, as extracting a large specimen through a small oral incision presents challenges (11). This limitation, however, can be addressed by incorporating an additional axillary port.

Contraindications for remote-access thyroidectomy and LND include extensive invasion of the primary tumor into adjacent structures, such as the recurrent laryngeal nerve (RLN), trachea, larynx, or esophagus, although minimal extrathyroidal extension is considered acceptable. Additional contraindications are primary tumors exceeding 4 cm in diameter, bulky or multi-level nodal metastases in the lateral neck compartment, and a history of prior surgery or radiation in the neck or along the remote access pathway (12).

Relative contraindications include elevated body mass index (BMI) and severe thyroiditis. Patients with a BMI exceeding 30 kg/m^2 or those with a short neck are generally unsuitable candidates for remote-access endoscopic or robotic surgery (13).

Furthermore, the indications for endoscopic and robotic LND techniques can be tailored and expanded based on factors such as the surgeon's experience, the stage and specific characteristics of the disease, and the selected surgical approach (11).

Discussion

Surgical approaches

Endoscopic gasless infraclavicular approach

The endoscopic gasless infraclavicular approach for thyroidectomy was first described by Shimizu *et al.* in 2001 as the video-assisted neck surgery (VANS) technique utilizing an infraclavicular incision (14). Subsequently, Kitagawa *et al.* and Lin *et al.* adapted this method for performing hemi- or total thyroidectomy as well as LND (15,16).

Surgical procedure

The procedure begins with the patient placed in a supine position, with a pillow positioned under the shoulders to facilitate gentle neck extension. A 4–5 cm skin incision is made on the anterior chest approximately 3–5 cm below the lower border of the ipsilateral clavicle. Subplatysmal dissection is conducted under direct visualization, with the working space maintained using either an external retractor or Kirschner wires. An additional 0.5–2.5 cm incision is created on the upper lateral neck to accommodate the endoscope (*Figure 2*) (15,16). Through the incision port, the harmonic scalpel and grasper are introduced. Dissection is performed between the sternal and clavicular heads of the sternocleidomastoid (SCM) muscle, proceeding beneath the strap muscles to access the thyroid gland. LND is performed as indicated.

Outcomes and complications

Outcomes from two studies employing this approach are summarized in *Table 1*. In 2003, Kitagawa *et al.*

reported three cases of hemithyroidectomy with LND. The operative times ranged from 248 to 290 minutes, although the extent of LND and the number of lymph nodes retrieved were not specified (15). In 2021, Lin *et al.* presented a series of 31 cases involving thyroidectomy with LND via the infraclavicular approach (16). The mean operative time for this cohort was 135 minutes, notably longer than the 108 minutes reported for the conventional approach. The mean lateral neck lymph node yield was 18 (range, 16–21), comparable to the yield of 19 nodes in the conventional transcervical group. Importantly, no recurrences were observed during mean follow-up periods of 48 months for the infraclavicular group and 35 months for the conventional group. Functional outcomes, including parameters such as voice quality, swallowing, and arm mobility, were equivalent between the infraclavicular and conventional approaches. However, cosmetic satisfaction was notably higher in the infraclavicular group compared to the open approach. Postoperative complications were minimal, with one case of transient hypoparathyroidism in the infraclavicular cohort and two cases in the transcervical group; all resolved within 2 weeks. No RLN injuries or postoperative hemorrhages were reported in either study (15,16).

Advantages and limitations

The endoscopic gasless infraclavicular approach offers several advantages. It involves less extensive flap dissection compared to the transaxillary approach and BABA, and its gasless nature obviates the complications associated with CO_2 insufflation. However, this technique has limitations. Access to the contralateral thyroid lobe and CND in the tracheoesophageal groove is challenging. Additionally, the relatively prominent anterior chest scar may be considered cosmetically undesirable by some patients.

Endoscopic breast-chest approach

The breast approach using CO_2 insufflation for thyroidectomy was initially described by Ohgami *et al.* in 2000 (17). This technique involves the use of two breast ports and one parasternal port. However, the tendency for parasternal scars to hypertrophy has prompted various modifications to improve cosmetic outcomes. One such modification includes the addition of an axillary port, thereby eliminating the parasternal incision (18). Another refinement is the bilateral areolar approach, where the parasternal incision is relocated to the inner side of the areola, further enhancing cosmetic outcomes (19). The breast-chest approach has also been adapted for endoscopic LND (*Table 2*) (20-25).

Surgical procedure

The patient is positioned supine with a pillow under the shoulders to gently extend the neck. The surgeon operates while standing between the patient's extended legs (22). Two skin incisions are made at the upper margins of the bilateral mammary areolas, accompanied by a 1.2 cm parasternal skin incision at the level of the nipple (*Figure 3*). Blunt dissection of the subcutaneous tissue on the anterior chest wall is performed through the parasternal incision, and the working space is insufflated with CO_2 to a pressure of 6–8 mmHg. This working area extends superiorly to the thyroid cartilage and laterally to the medial borders of the SCM muscles (20). To maintain the working space, CO_2 insufflation can be supplemented with U-shaped retractors and Kirschner wires (23,24). The procedure includes endoscopic thyroidectomy, CND, and LND, covering levels II, III, and IV (22,24,25).

Outcomes and complications

The mean operative time for the breast-chest approach ranged from 196.3 to 338.2 minutes, which is significantly longer than the transcervical approach (20-25). The extent of LND achieved with this method encompasses levels II to IV, with a mean lateral lymph node yield of 18.3 to 33.5, comparable to the conventional approach (20-25). This approach demonstrates less neck discomfort and superior cosmetic outcomes compared to the conventional approach (20,23).

The complication profile reveals a higher incidence of internal jugular vein (IJV) rupture compared to the conventional approach (12.26% *vs.* 2.94%, P<0.01) (23). However, most IJV injuries were minor tears that were successfully repaired endoscopically, with no conversions to open surgery required. Among 274 patients reported in the literature, complications included one case of permanent hypoparathyroidism (0.4%), 17 cases of temporary hypocalcemia (6.2%), 12 cases of temporary RLN palsy (4.4%), and 8 cases of chyle leaks (2.9%). Less common complications included spinal accessory nerve injury (1.5%), Horner's syndrome (0.4%), and hypoglossal nerve injury (0.4%). There was one reported case of tumor recurrence in the subcutaneous tunnel and operative bed, highlighting the importance of rigorous measures to prevent tumor seeding during remote-access procedures.

Table 1 Characteristics and outcomes of the endoscopic infraclavicular approach

Author (year of publication/country)	Study design	No. of cases (M:F)	Surgical method	Main incisions	Auxiliary incisions	Maintaining the working space	Operative time, mean [range] (min)	Lateral neck levels dissected	Lateral lymph node yield, mean	Complications [n]	Mean follow-up (months)/ number & site of recurrences
Kitagawa *et al.* (15) (2003, Japan)	Retrospective/case series	3 (0:3)	Endoscopic	3.5-cm incision on the chest wall, 3–5 cm below the clavicle	0.5-cm incision in the upper lateral neck	Two pieces of Kirschner wire and fixation devices	248–290	NA	NA	None	NA
Lin *et al.* (16) (2021, China)	Retrospective/comparative (endoscopic *vs.* open)	31 (11:20)	Endoscopic	4–5 cm incision below the clavicle	2.5-cm incision in the upper lateral neck	An external retractor	135 [114–156]	II–V	18	Transient hypocalcemia [1]	48/none

NA, not available.

Table 2 Characteristics and outcomes of the endoscopic breast-chest approach

Author (year of publication/country)	Study design	No. of cases (male:female)	Surgical method	Main incisions	Maintaining the working space	Operative time, mean [range] (min)	Lateral neck levels dissected	Lateral lymph node yield, mean [range]	Complications [n]	Mean follow-up (months)/ number & site of recurrences
Li *et al.* (20) (2011, China)	Retrospective/case series	11 (0:11)	Endoscopic	1.2-cm incision parasternal at nipple level and two 0.5-cm incisions at the upper margin of bilateral mammary areolas	CO_2 insufflation & a U-shape wire retractor	196.3 [172–230]	III–IV	18.3 [9–26]	None	5.6/none
Yan *et al.* (21) (2015, China)	Retrospective/case series	12 (0:12)	Endoscopic	Similar to the above	Similar to the above	243 [165–355]	II–IV	21.8 [5–42]	Transient hypocalcemia [1]; IJV injury [1]	NA
Wang *et al.* (22) (2019, China)	Retrospective/case series	37 (2:35)	Endoscopic	Similar to the above	Similar to the above	338.2 [225–450]	II–IV	33.5 [5–56]	Transient hypocalcemia [12]; permanent hypocalcemia [1]; transient RLN palsy [3]; accessory nerve injury [1]; Horner's syndrome [1]; chyle leak [1]	24/1, level VII
Qu *et al.* (23) (2020, China)	Retrospective/case series	24 (2:22)	Endoscopic	Similar to the above	Similar to the above	238.8 [170–300]	II–IV	21.8 [13–35]	Transient hypocalcemia [4]; transient RLN palsy [1]; chyle leak [2]; large blood vessel injury [2]	12/1, lung metastasis
Yan *et al.* (24) (2021, China)	Retrospective/comparative (endoscopic *vs.* open)	155 (6:149)	Endoscopic	Similar to the above	Similar to the above	278.2	II–IV	22.91	Transient RLN palsy [8]; hematoma [3]; chyle leak [4]; IJV rupture [19]; limb lift restriction [6]	NA/2, NA
Chen *et al.* (25) (2022, China)	Retrospective/case series	35 (8:27)	Endoscopic	Similar to the above	Similar to the above	307.5 [190–455]	II–IV	24.2	Chyle leak [1]; cervical plexus injury [7]; accessory nerve injury [3]; hypoglossal nerve injury [1]; IJV injury [2]	18.1/none

IJV, internal jugular vein; NA, not available; RLN, recurrent laryngeal nerve

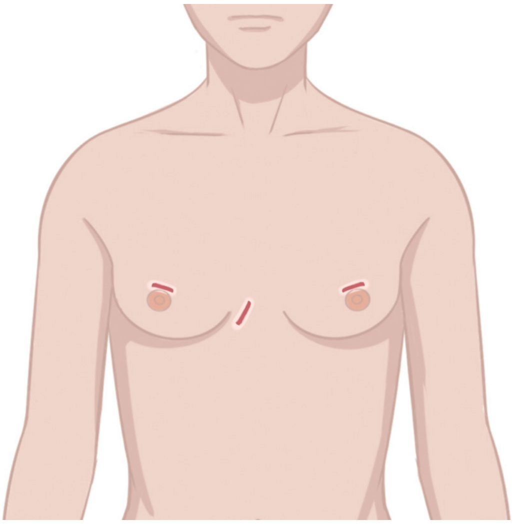

Figure 3 Endoscopic breast-chest approach.

Advantages and limitations

The primary advantage of the breast-chest approach is its superior cosmetic outcomes, as it avoids a visible anterior neck scar. Additionally, its midline access facilitates bilateral total thyroidectomy more effectively than unilateral techniques such as the transaxillary or retroauricular approaches. However, the approach presents challenges in dissecting levels IV and VI due to potential blind spots around the clavicle, where the clavicle and manubrium may obstruct the downward view.

Robotic gasless transaxillary approach

The transaxillary approach for thyroidectomy was first reported in 2000 by Ikeda *et al.* using an endoscopic procedure with CO_2 insufflation (26). Subsequently, Yoon *et al.* introduced the gasless endoscopic transaxillary approach without CO_2 insufflation in 2006 (27). With advancements in surgical technology, the robotic gasless transaxillary approach was first performed in 2009 (28). This transaxillary robotic technique provides an adequate surgical view of the thyroid and lateral neck compartment, with sufficient entry space for three robotic instruments. Total thyroidectomy and LND are feasible when performed by experienced surgeons. The method has gained significant traction, particularly in South Korea, where eight studies have been published, including one utilizing the da Vinci single-port (SP) robotic system (Intuitive Surgical, Inc., Sunnyvale, CA, USA). These studies report LND encompassing levels II, III, and IV, with some extending to level Vb (*Table 3*) (29-36). The largest case series comprised 500 patients over 11 years (35).

Surgical procedure

The patient is positioned supine with the neck extended, while the arm on the side of the lesion is positioned at an 80° extension or a 90° "salute" flexion. A 6–7 cm skin incision is made in the axillary fossa (*Figure 4A*), and a skin flap is elevated under direct visualization along the subplatysmal plane over the pectoralis major muscle. This dissection extends from the axilla to the anterior neck area. The surgical plane is further developed between the two heads of the SCM muscle and continues beneath the sternothyroid muscle to expose the thyroid gland. An external retractor is used to maintain sufficient working space without requiring CO_2 insufflation. Initially, Kang *et al.* introduced an auxiliary 0.8 cm incision on the medial side of the anterior chest wall for the insertion of a fourth robotic arm (*Figure 4B*) (29). Tae *et al.* employed an auxiliary 0.8 cm incision along the circumareolar margin of the breast for the placement of a third robotic instrument in their early cases (*Figure 4C*) (32). To avoid the circumareolar incision, Song *et al.* later adopted a 0.8 cm auxiliary incision just below the primary axillary incision for trocar insertion (*Figure 4D*) (34). The auxiliary axillary incision minimizes the length of the main axillary incision. Through the primary axillary incision port, three robotic arms are inserted, while the auxiliary trocar accommodates the additional robotic arm.

For LND, the patient's head is rotated contralaterally to the unaffected side to create sufficient working space. Throughout the operation, adjustments to the patient's position are necessary, depending on the neck levels being targeted. The external retractor and robotic surgical axis are repositioned to access level II and levels III–V. Specifically, to access level II, the arm is brought closer to the body to optimize retractor placement and improve exposure to the upper neck.

Outcomes and complications

The mean operative time reported across studies ranged from 271 to 329 minutes, with the robotic gasless transaxillary approach demonstrating a significantly longer duration compared to conventional techniques.

A meta-analysis revealed no statistically significant differences between remote-access approaches—such as the

Table 3 Characteristics and outcomes of the robotic gasless transaxillary approach

Author (year of publication/country)	Study design	No. of cases (male:female)	Surgical method	Main incisions	Auxiliary incisions	Maintaining the working space	Operative time, mean [range] (min)	Lateral neck levels dissected	Lateral lymph node yield, mean [range]	Complications [n]	Mean follow-up (months)/number & site of recurrences
Kang *et al.* (29) (2010, Korea)	Retrospective/case series	33 (7:26)	Robotic	7–8 cm incision in the axillary fossa	Additional 0.8 cm anterior chest skin incision	An external retractor	280.8 [186–357]	IIa, III, IV, Vb	27.7 [12–58]	Transient hypocalcemia [17]; transient RLN palsy [2]; seroma [4]; chyle leak [3]	14/none
Kang *et al.* (30) (2012, Korea)	Retrospective/comparative (robot *vs.* open)	56 (10:46)	Robotic	Similar to the above	Similar to the above	An external retractor	277.4	IIa, III, IV, Vb	31.1	Transient hypocalcemia [27]; transient RLN palsy [2]; seroma [5]; hematoma [1]; chyle leak [5]	12/none
Lee *et al.* (31) (2013, Korea)	Retrospective/comparative (robot *vs.* open)	62 (5:57)	Robotic	Similar to the above	None	An external retractor	271.8	IIa, III, IV, Vb	32.8	Transient hypocalcemia [24]; transient RLN palsy [2]; chyle leak [1]	8.4/none
Tae *et al.* (32) (2014, Korea)	Retrospective/case series	12 (0:12)	Robotic	6–8 cm incision in the axillary fossa	0.8 cm incision on the circumareolar margin	An external retractor	310 [230–440]	IIa, III, IV, Vb	22.3 [14–32]	Transient hypocalcemia [5]; transient RLN palsy [1]; seroma [3]; chyle leak [1]	12.9/none
Song *et al.* (33) (2015, Korea)	Retrospective/comparative (with charcoal tattoo *vs.* without)	10 (1:9) *vs.* 11 (0:11)	Robotic	Similar to the above	Similar to the above	An external retractor	329.0 *vs.* 298.2	IIa, III, IV, Vb	32.80 *vs.*19.82	Seroma [1 *vs.* 0]; chyle leakage [1 *vs.* 1]; transient hypocalcemia [5 *vs.* 5]	19.7/none *vs.* 38.0/1, level III
Song *et al.* (34) (2016, Korea)	Retrospective/comparative (robot *vs.* open)	25 (1:24)	Robotic	6–8 cm incision in the axillary fossa	Second 0.5 cm incision just below the main axillary incision	An external retractor	298	IIa, III, IV, Vb	24.72	Transient hypocalcemia [11]; transient RLN palsy [1]; seroma [1]; chyle leak [2]	29.0/1, level III
Kim *et al.* (35) (2022, Korea)	Retrospective/case series	500 (106:394)	Robotic	7–8 cm incision in the axillary fossa	None	An external retractor	283.13 [142–555]	IIa, III, IV, Vb	36.02 [8–146]	Transient hypocalcemia [152]; permanent hypocalcemia [20]; transient RLN palsy [20]; permanent RLN injury [5]; seroma [16]; hematoma [3]; chyle leak [26]; Horner's syndrome [2]	NA/5, level VI ×4, contralateral neck ×1
Ho *et al.* (36) (2023, Korea)	Retrospective/case series (SP robot)	30 (0:30)	Robotic	5 cm incision in the axillary fossa	None	An external retractor	293.8	IIa, III, IV, Vb	34.6	Transient hypocalcemia [6]; transient RLN palsy [1]; seroma [1]; chyle leak [1]	NA/NA

NA, not available; RLN, recurrent laryngeal nerve; SP, single-port.

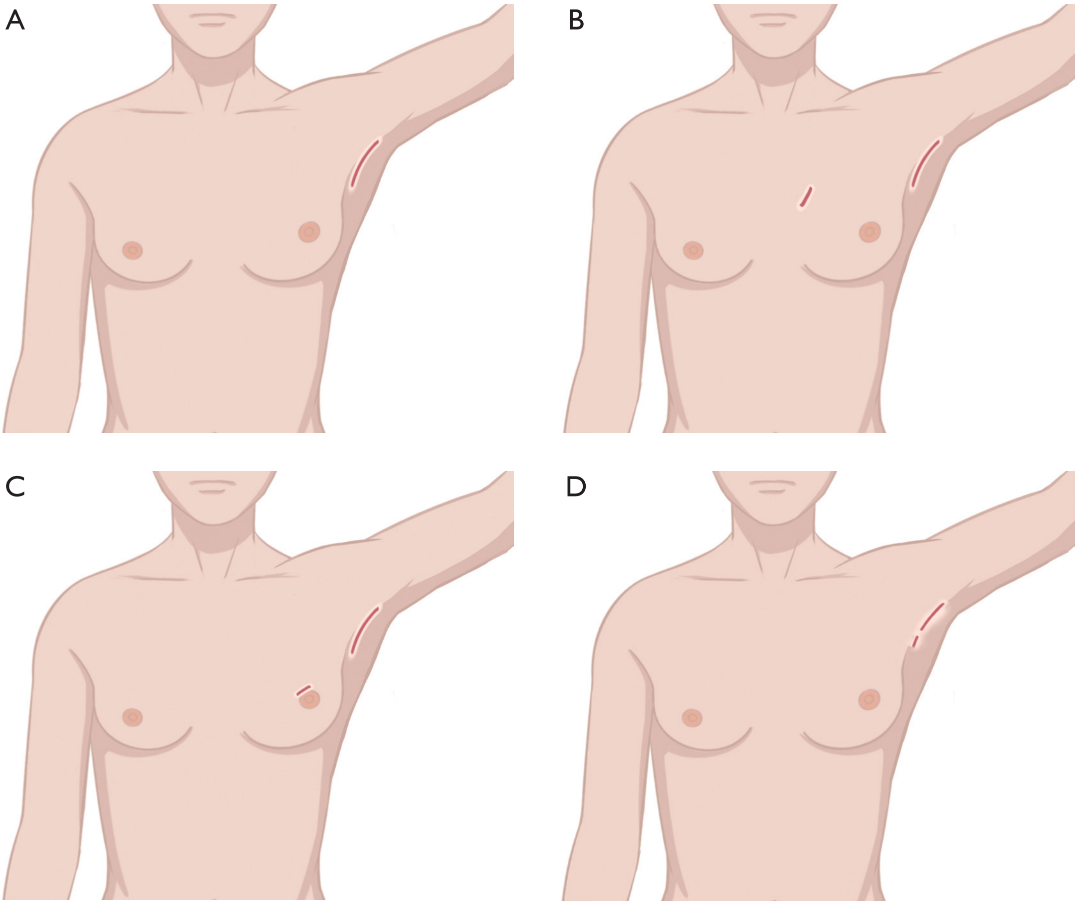

Figure 4 Robotic gasless transaxillary approaches. (A) A single transaxillary incision; (B) transaxillary approach with an anterior chest incision; (C) transaxillary approach with a breast incision; (D) transaxillary approach with a secondary axillary incision.

robotic gasless transaxillary approach, robotic BABA, and endoscopic breast-chest approach—and the conventional procedure in terms of the number of lateral lymph nodes removed, the extent of LND, transient RLN palsy and hypoparathyroidism rates, serum-stimulated thyroglobulin levels, or recurrence rates (10).

Complications were observed in a cohort of 739 patients across the literature, including 20 cases of permanent hypoparathyroidism (2.7%), 252 cases of temporary hypocalcemia (34.1%), 29 cases of temporary RLN palsy (3.9%), 5 cases of permanent RLN palsy (0.7%), and 41 cases of chyle leaks (5.6%). Temporary hypocalcemia was notably more prevalent with remote-access approaches than with conventional methods.

Regarding postoperative pain, several studies reported no significant differences between the transaxillary and conventional approaches. However, Song *et al.* documented that patients undergoing the gasless transaxillary approach experienced higher levels of anterior chest pain and paresthesia during the first postoperative month; these differences were no longer significant by the third month (34). Cosmetic satisfaction, as measured by patient-reported questionnaires, was significantly higher in the transaxillary approach group compared to the conventional approach (31).

Advantages and limitations

The feasibility of the robotic gasless transaxillary approach has been substantiated by multiple studies. This technique offers several advantages, including a gasless surgical field that ensures clear visibility while avoiding complications associated with carbon dioxide insufflation. The lateral surgical view reduces the risk of RLN injury and provides superior exposure of level Vb lymph nodes.

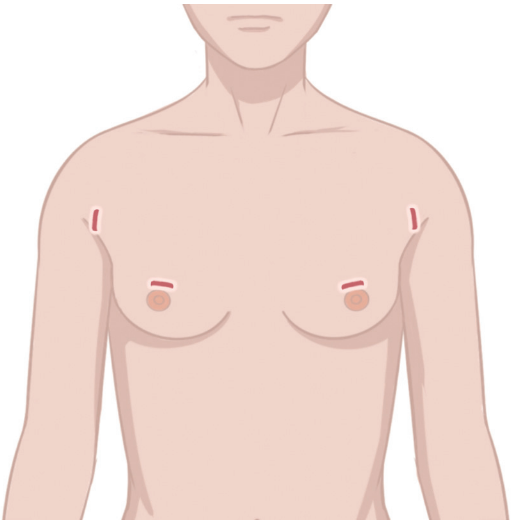

Figure 5 Robotic bilateral axillo-breast approach.

However, the unilateral nature of this approach presents certain challenges. The single incision restricts access to the contralateral thyroid lobe. Dissection in the level IIb region also remains technically demanding. Additionally, the extensive dissection area required to create the working space contributes to increased surgical morbidity. Recent advances, such as the development of the da Vinci SP surgical robot system (Intuitive Surgical, Inc.), have mitigated some of these limitations. This system allows for a reduced dissection area, and a smaller axillary incision (4–5 cm), and eliminates the need for auxiliary incisions (36).

Robotic BABA

The BABA was first introduced in South Korea in 2007 by Choe *et al.*, initially for thyroidectomy and subsequently extended to include LND (37). This technique involves four skin incisions distributed across both axillae and the breast areolar margins (*Figure 5*) and has gained substantial popularity, particularly in Asia. Key studies investigating robotic BABA for total thyroidectomy and LND are summarized in *Table 4* (38-43).

Surgical procedure

The patient is positioned supine on the operating table with the neck extended to optimize surgical exposure, supported by a pillow placed beneath the shoulders. To facilitate access to the axillae, the arms are abducted (44). An elastic bandage supports the lower portion of the breast, elevating the areolar area to enhance visualization of the lower neck region and eliminate blind spots (38).

Four incisions are created: a 12 mm incision above the right areola for the robotic endoscope, an 8 mm incision above the left areola, and two 8 mm incisions in the bilateral axillary regions. After docking the robotic system, an ultrasonic scalpel is employed to establish a working space, maintaining insufflation pressure at 5–6 mmHg. The working space is extended superiorly to the submandibular gland and posterior belly of the digastric muscle, laterally to the anterior edge of the trapezius, and inferiorly to the clavicle. The surgical procedure includes total thyroidectomy followed by CND and LND of levels II–V. The SCM is dissected to expose the IJV and lymph nodes. To access levels IIa and III, the medial side of the SCM is retracted laterally. A longitudinal division of the SCM is performed to fully expose levels IV and Vb (44). The BABA approach provides a symmetrical bilateral view, enabling comprehensive bilateral neck lymph node dissection without the need for repositioning robotic instruments.

Outcomes and complications

The BABA group demonstrated a significantly longer operative time compared to traditional surgery. However, Choi *et al.* reported that, after excluding the time required for flap elevation, the actual operative time for the BABA approach was comparable to that of the transcervical approach (200.3 *vs.* 191.4 minutes, P=0.52) (43).

The number of lymph nodes retrieved ranged from 21.17 to 36.5, with no significant difference observed between the BABA and conventional groups (38-43).

Among a total of 332 patients who underwent robotic BABA thyroidectomy and LND, 62 patients (18.7%) experienced transient hypocalcemia. Transient RLN palsy occurred in 8 patients (2.4%), while 1 patient (0.3%) developed permanent RLN palsy. Four cases of chyle leak were reported across three studies, all were successfully managed conservatively. Additionally, there was a single case of tracheal fistula caused by ultrasonic scalpel cauterization.

He *et al.* reported that all 260 patients in their study experienced some degree of sensory loss in the anterior chest, nipples, or neck, though sensation typically returned within 4 to 12 months (41). Patient satisfaction with cosmetic outcomes was consistently rated as “satisfied” or “highly satisfied” (41).

One case of recurrence was noted in the study by He *et al.*, which necessitated a second open surgery for metastatic

Table 4 Characteristics and outcomes of the robotic bilateral axillo-breast approach

Author (year of publication/ country)	Study design	No. of cases (male:female)	Surgical method	Main incisions	Maintaining the working space	Operative time, mean [range] (min)	Lateral neck levels dissected	Lateral lymph node yield, mean [range]	Complications [n]	Mean follow-up (months)/ number & site of recurrences
Kim *et al.* (38) (2015, Korea)	Retrospective/comparative (robot *vs.* open)	13 (2:11)	Robotic	A 12 mm upper circumareolar incision for the camera port and three 8 mm incisions in both axilla and another upper circumareolar	CO_2 insufflation	382.3 [320–460]	II–IV, Vb	28.9 [8–50]	Chyle leakage [1]	13.2/none
Yu *et al.* (39) (2018, Korea)	Retrospective/case series	15 (1:14)	Robotic	Similar to the above	CO_2 insufflation	272.7	IIa, III, IV, Vb	20.7	Transient hypocalcemia [7]; transient RLN palsy [1]; Horner's syndrome [1]	18.7/none
Paek *et al.* (40) (2020, Korea)	Retrospective/comparative (robot *vs.* open)	28 (6:22)	Robotic	Similar to the above	CO_2 insufflation	382.3	II–IV	36.5	Transient hypocalcemia [2]; transient RLN palsy [3]; permanent RLN palsy [1]; chyle leak [1]	NA
He *et al.* (41) (2020, China)	Retrospective/case series	260 (63:197)	Robotic	Similar to the above	CO_2 insufflation	201	II–IV, Vb	17.9	Transient hypocalcemia [51]; transient RLN palsy [3]; seroma [3]; surgical site infection [1]; tracheal fistula [1]; chyle leak [2]	28.6/1 (level IV)
Song *et al.* (42) (2020, Korea)	Retrospective/case series	4 (2:2)	Robotic	Similar to the above	CO_2 insufflation	533 [500–565]	Bilateral II–IV	54.5 [48–65]	Pleural effusion [not chylous]	17–36/none
Choi *et al.* (43) (2021, Korea)	Retrospective/comparative (robot *vs.* open)	12 (3:9)	Robotic	Similar to the above	CO_2 insufflation	277.08	II–V	21.17	Transient hypocalcemia [2]; transient RLN palsy [1]	NA /none

NA, not available; RLN, recurrent laryngeal nerve.

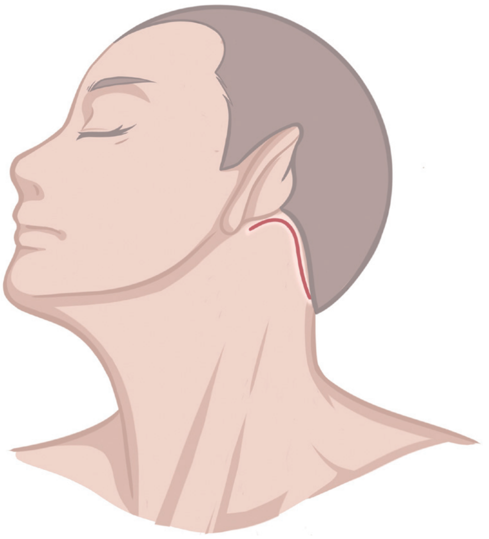

Figure 6 Robotic gasless retroauricular approach.

lymph node removal. Follow-up duration for this cohort ranged from 13.2 to 28.6 months (41).

Advantages and limitations

The BABA technique offers several advantages, including a symmetrical bilateral view of anatomical structures, which many surgeons find familiar and easier to adapt to. Throughout thyroidectomy and LND procedures, the technique obviates the need to adjust the patient's position or reposition the robotic arms, facilitating a smoother surgical workflow. This approach allows for the performance of total thyroidectomy and bilateral LND via a single incision strategy. However, the creation of a working space necessitates a higher degree of surgical invasiveness compared to other remote-access techniques. Although postoperative cosmetic outcomes are generally excellent, areolar incisions may be less favored by some patients.

Performing CND can present challenges due to limited access to the central neck compartment, as the clavicle and manubrium may obstruct the downward view. This limitation can be mitigated by employing an elastic band to elevate the areolar region and improve visualization of the lower neck area (38).

Robotic gasless retroauricular approach

In 2011, Terris *et al.* introduced the facelift (retroauricular) approach for thyroidectomy utilizing robotic surgical systems (45). Building on this innovation, Byeon *et al.* reported the first series of robot-assisted total thyroidectomy and LND performed via the unilateral retroauricular approach in 2014, comprising four cases (46). Subsequently, in 2018, Lira *et al.* described 12 cases of robotic total thyroidectomy with LND employing this technique (47).

Surgical procedure

The patient's head is positioned with a 30° rotation away from the side undergoing neck dissection. The incision follows the postauricular sulcus, beginning at the lower end and extending to the midpoint of the postauricular fold, then curving along the hairline toward the occipital region (*Figure 6*). A skin flap is meticulously elevated over the SCM muscle, extending medially to the midline, with careful preservation of the great auricular nerve. Inferior dissection extends to the clavicle, while superior dissection reaches the submandibular gland. An external retractor maintains the working space without the need for CO_2 insufflation. Level II dissection can often be performed under direct vision, although robotic assistance is sometimes utilized. Dissection of levels III, IV, and V is typically achieved using robotic instruments.

For contralateral thyroid lobectomy, optimal exposure necessitates tilting or rotating the patient 15°–30° toward the surgeon (ipsilateral side downward, contralateral side upward). Additionally, an assistant's application of gentle downward pressure on the trachea using a suction tip facilitates the robotic dissection (46).

Outcomes and complications

There are limited reports of thyroidectomy combined with LND using the gasless retroauricular approach (*Table 5*) (46,47). In Byeon *et al.*'s study (46), four female patients underwent total thyroidectomy and LND encompassing levels II–V. The mean operative time was 306.3 minutes, and the mean number of lymph nodes retrieved was 33.3. Similarly, Lira *et al.* (47) reported an average operative time of 340 minutes and an average of 27.8 lateral neck lymph nodes retrieved. Reported complications include transient hypocalcemia, transient RLN palsy, and chyle leakage.

Advantages and limitations

The retroauricular approach involves a more localized dissection area compared to the BABA and the transaxillary approach. Additionally, the absence of CO_2 insufflation minimizes complications associated with its use. This technique provides excellent exposure to the lateral neck compartment, enabling comprehensive LND, including levels II, III, IV, and V. However, the narrow working space and challenges in accessing the contralateral thyroid lobe via a unilateral incision present notable limitations. Consequently, this approach is considered most appropriate for isolated thyroid lobectomy, with or without LND. Postoperative cosmesis is generally favorable. However, the postauricular scar demonstrates a higher propensity for hypertrophic changes compared to the conventional thyroidectomy scar (48).

Endoscopic and robotic transoral approach

The transoral vestibular approach, originally developed as a Natural Orifice Transluminal Endoscopic Surgery (NOTES) technique for endoscopic thyroidectomy, has gained substantial global popularity in recent years (13,49-52). Currently, the endoscopic procedure utilizing three vestibular incisions is more commonly performed than the robotic approach due to its advantages, including shorter operative times and reduced costs. In contrast, transoral robotic thyroidectomy typically incorporates an additional axillary port for the insertion of a third robotic instrument. This instrument facilitates countertraction, akin to conventional thyroidectomy, and is particularly beneficial for enhancing the removal of the superior pole. Furthermore, the axillary port provides an effective route for the removal of larger specimens. Recently, this approach has been extended to LND, with a few reports detailing the use of both endoscopic and robotic techniques (*Table 6*) (13,49-51). However, as a midline approach, it presents limitations in LND, with the extent of LND generally restricted to levels III and IV.

Surgical procedure

The patient is placed in the supine position with a shoulder pillow to achieve optimal neck extension, and general anesthesia is administered via oral or nasal intubation. The transoral endoscopic approach is performed using a three-port technique in the oral vestibule (*Figure 7A*). A horizontal incision measuring 1.5–2 cm is made at the base of the lower lip frenulum, with lateral incisions placed near the corners of the mouth, carefully avoiding injury to the mental nerve. A working space is developed via hydrodissection with an epinephrine solution, followed by blunt dissection using dilators down to the sternal notch inferiorly and bilaterally to the SCM muscle through the subplatysmal layer. Trocars are inserted, and CO_2 insufflation pressure is maintained at 5–6 mmHg. For LND, Tan *et al.* performed dissections of levels III and IV using three vestibular ports (13). In contrast, Ngo *et al.* employed an additional 5 mm trocar near the right sixth tooth to facilitate dissection of level II (50).

The LND procedure mirrors that of other techniques, with dissection of the SCM to expose the IJV and associated lymph nodes. The omohyoid muscle is often removed to enhance the surgical field and facilitate dissection. In endoscopic procedures, external hanging sutures are employed to retract the SCM, improving visualization.

In the transoral robotic approach (*Figure 7B*), blunt dissection is initially performed in the submental area. The working space is created in the subplatysmal layer using endoscopic techniques inferior to the thyroid notch, sufficient for robotic instrument placement (49). Once the initial working space is established, the robotic arms are docked. The skin flap is subsequently extended inferiorly to the sternal notch and laterally to the lateral border of the SCM using the surgical robot. An additional axillary port is created at the right axillary fossa for the placement of a third robotic instrument, such as ProGrasp or Cardinal forceps. This additional instrument facilitates countertraction, similar to conventional thyroidectomy. The axillary port also serves as an effective pathway for the removal of larger specimens and for the placement of drainage. For LND, dissection of levels III and IV is performed in accordance with standard protocols (51).

Outcomes and complications

In a case series by Tan *et al.*, evaluating the endoscopic procedure in 20 patients, the mean operative time was reported as 146 minutes, whereas Tae's study on the robotic procedure documented a significantly longer mean operative time of 299 minutes. Despite the prolonged duration, the robotic approach demonstrated superior efficacy in terms of lymph nodal yield. Specifically, Tan *et al.* reported an average retrieval of 10.9 lymph nodes (range: 6–16) from the lateral neck, while Tae *et al.* observed a mean of 23.1 nodes retrieved (range, 10–40). The relatively lower lymph nodal yield compared to conventional LND may be attributable to the exclusion of level II dissections in these approaches. Reported complications included transient RLN palsy, transient hypoparathyroidism, and chyle leakage. Due to the limited sample sizes in both studies, comprehensive statistical analyses were not performed. The mean follow-up durations were 24.3 and 14.5 months, respectively, with no structural recurrences detected during

Table 5 Characteristics and outcomes of the robotic gasless retroauricular approach

Author (year of publication/country)	Study design	No. of cases (male:female)	Surgical methods	Main incisions	Maintaining the working space	Operative time, mean [range] (min)	Lateral neck levels dissected	Lateral lymph node yield, mean [range]	Complications [n]	Mean follow-up (months)/ number & site of recurrences
Byeon *et al.* (46) (2014, Korea)	Retrospective/case series	4 (0:4)	Robotic	The incision extends along the postauricular sulcus, curving at the hairline toward the occipital area	An external retractor	306.3 [295–320]	II–V	33.3 [23–48]	Seroma [1]; transient hypocalcemia [2]; chyle leakage [1]	11.3/none
Lira *et al.* (47) (2018, Brazil)	Retrospective/case series	12 (1:11)	Robotic	Similar to the above	An external retractor	340	II–V	27.8	Transient hypocalcemia [2]; transient RLN palsy [3]	17.4/none

RLN, recurrent laryngeal nerve.

Table 6 Characteristics and outcomes of the endoscopic and robotic transoral approach

Author (year of publication/country)	Study design	No. of cases (male:female)	Surgical methods	Main incisions	Auxiliary incisions	Maintaining the working space	Operative time, mean [range] (min)	Lateral neck levels dissected	Lymph node yield, mean [range]	Complications [n]	Mean follow-up (months)/ number & site of recurrences
Tan *et al.* (13) (2020, China)	Retrospective/case series	20 (1:19)	Endoscopic	1.5–2 cm horizontal incision at the lower lip frenulum and 0.5–0.8 cm lateral incisions near the corners of the mouth	None	CO_2 insufflation	146 [114–193]	III, IV	10.9 [6–16]	Transient RLN palsy [1]; seroma [2]	24.3/none
Tae *et al.* (49) (2020, Korea)	Case report	1 (0:1)	Robotic	1.5 cm incision at the base of the lower lip frenulum and two 0.8 cm incisions near the corners of the mouth	1 cm incision in the right axillary fossa	CO_2 insufflation	295	III, IV	29	None	NA
Ngo *et al.* (50) (2021, Vietnam)	Case report	1 (0:1)	Endoscopic	1.0 cm horizontal incision at the base of the lower lip frenulum and two 0.5 cm vertical incisions between the incisor and canine on both sides	0.5 cm incision was made near the sixth teeth in the oral vestibular	CO_2 insufflation	170	II–IV	8	None	NA
Tae *et al.* (51) (2022, Korea)	Retrospective/case series	10 (1:9)	Robotic	1.5 cm incision at the base of the lower lip frenulum and two 0.8 cm incisions near the corners of the mouth	1 cm incision in the right axillary fossa	CO_2 insufflation	299 [235–360]	III, IV	23.1 [10–40]	Transient hypocalcemia [2]; transient RLN palsy [1]; chyle leak [1]; seroma [2]	14.5/none

NA, not available; RLN, recurrent laryngeal nerve.

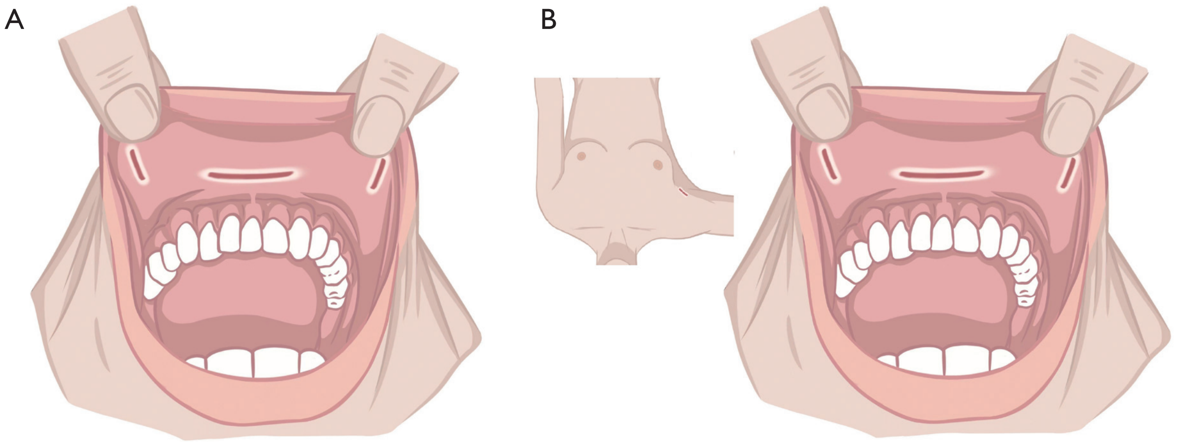

Figure 7 Transoral approach: (A) endoscopic procedure, (B) robotic procedure with an incision in the right axillary fossa.

imaging follow-ups (13,51).

Tae *et al.*'s study also reported one instance of intraoperative conversion during the transoral robotic LND due to uncontrollable bleeding caused by a minor tear in the IJV. In this case, the procedure was converted to a gasless postauricular approach to accommodate the patient's strong preference for scarless neck surgery (51).

Advantages and limitations

A major advantage of this approach is the excellent cosmetic outcome, as no visible cutaneous skin incision is required, except for a small axillary incision in the transoral robotic procedure. Additionally, this approach creates the smallest working space among remote-access techniques. The midline, top-down view provides enhanced access to both thyroid lobes and the lower central compartments, including levels VI and VII. Furthermore, the approach facilitates adequate dissection of levels III and IV lymph nodes.

However, dissection of level II lymph nodes poses significant challenges due to the limited surgical axis, suboptimal visualization, and restricted instrument reach. Given those metastases in PTC are most frequently observed in levels III and IV, and approximately 20% of patients present with single-level metastasis in these regions, this technique is particularly suitable for patients with isolated involvement of levels III and IV. When level II dissection is necessary, incorporation of the postauricular approach provides effective access and facilitates dissection in this region (51).

For the robotic procedure, despite its technical advantages, the initial creation of the working space still requires endoscopic techniques. This necessitates the use of both endoscopic and robotic system equipment, potentially increasing procedural complexity and resource requirements.

Combined approaches

Combined approaches have been reported to achieve comprehensive LND and optimal surgical outcomes, addressing the limitations of single-access approaches that may not provide sufficient access to all lateral neck levels (*Table 7*).

These combined techniques compensate for the constraints of individual approaches but also increase the complexity of the procedure. Specifically, the necessity of a second incision and additional cavity creation significantly prolongs operative time and demands greater effort from the surgical team.

Endoscopic and robotic breast and transoral approach

Four studies have investigated the combined use of breast and transoral approaches for total thyroidectomy with LND. Three of these studies employed endoscopic techniques, primarily using the breast approach for total thyroidectomy, CND, and LND of levels II, III, and IV. The transoral approach was utilized to dissect and remove lymph nodes in levels VI and IV (53-55). In contrast, one study employed a robotic procedure that prioritized the transoral approach for total thyroidectomy, CND, and LND of levels III and IV, while using the breast approach for the dissection of level II lymph nodes (56).

The reported operative times for these combined

Table 7 Characteristics and outcomes of combined approaches

Author (year of publication/country)	Study design	No. of cases (male:female)	Combined approaches/ surgical method	Maintaining the working space	Operative time, mean [range] (min)	Lateral neck levels dissected	Lymph node yield, mean [range]	Complications [n]	Mean follow-up (months)/ number & site of recurrences
Kuang *et al.* (53) (2022, China)	Retrospective/case series	13 (1:12)	Breast & transoral/endoscopic	CO_2 insufflation	362.1 [268–497]	II–IV	36.6 [14–61]	Transient hypocalcemia [2]; transient chin numbness [3]	59/none
Chen *et al.* (54) (2022, China)	Retrospective/case series	24 (3:21)	Breast & transoral/endoscopic	CO_2 insufflation	298.1	II–IV	29.9	Transient hypocalcemia [10]; transient RLN palsy [1]; chyle leak [1]; IJV injury [1]	7.9/none
Wang *et al.* (55) (2023, China)	Retrospective/comparative (two modified procedures)	12 (3:8) *vs.* 13 (4:9)	Breast & transoral/endoscopic	CO_2 insufflation	256.0 *vs.* 336.9	II–IV	32.3 *vs.* 27.1	Transient hypocalcemia [5]; transient RLN palsy [2]; accessory nerve injury [1]; Horner's syndrome [1]	NA
Zhou *et al.* (56) (2023, China)	Retrospective/case series	26 (1:25)	Breast & transoral/robotic	CO_2 insufflation	313 [228–425]	II–IV	21.5	Transient hypocalcemia [3]; transient RLN palsy [2]	9/none
Kim *et al.* (57) (2014, Korea)	Retrospective/comparative (robot *vs.* open)	22 (5:17)	Transaxillary & retroauricular/ robotic	An external retractor	209.4	II–V	33.14	Transient hypocalcemia [6]; transient RLN palsy [2]; hematoma [1]; seroma [2]; chyle leak [1]; ear lobe numbness [6]	15.9/none
Tae *et al.* (51) (2022, Korea)	Retrospective/case series	4 (2:2)	Transoral & retroauricular/ robotic	CO_2 insufflation; an external retractor	431.3 [390–510]	II–V	38.3 [30–47]	Seroma [2]; transient hypocalcemia [1]	14.5/none

IJV, internal jugular vein; NA, not available; RLN, recurrent laryngeal nerve.

approaches ranged from 256.0 to 362.1 minutes, exceeding the durations typically observed for breast-chest approach procedures. Lymph node yield from the lateral neck ranged from 21.5 to 36.6 across the four studies, comparable to the breast-chest approach and notably higher than yields from the transoral approach alone. The transoral approach is particularly valuable for overcoming the limitations posed by the breast-chest approach, where the surgical field may be obstructed by anatomical structures such as the sternal manubrium and clavicles. This obstruction can impair visibility in the central neck compartment and for lymph nodes located between the SCM and sternohyoid muscles, increasing the risk of incomplete dissections. By contrast, the transoral approach provides superior exposure to these critical areas, enhancing the completeness of LND. Consequently, combining the transoral and breast approaches facilitates thorough and effective lymph node clearance (53).

Across the four studies, which included a total of 88 patients, transient hypocalcemia occurred in 20 cases (22.7%), and transient RLN palsy was observed in 8 cases (9.1%). Additionally, there was one case of Horner's syndrome, accessory nerve injury, and chyle leak. Notably, no tumor recurrence was reported during follow-up periods ranging from 7.9 to 59 months.

Robotic transaxillary and retroauricular (TARA) approach

Kim *et al.* reported 22 cases of PTC with cervical lymph node metastases managed using the robotic TARA approach (57). The authors highlighted that while robotic LND via the transaxillary approach is technically feasible, it remains limited in its ability to access the upper neck regions, including levels II and VA. In this study, upper neck dissection (encompassing levels IIa, IIb, Va, and the upper level III) was achieved under direct visualization through a retroauricular incision. Among the 22 patients, the mean operative time for LND was 209.4 minutes. The lateral compartment lymph node yield averaged 33.14 nodes. Importantly, the incidence of surgical complications did not significantly differ from that observed in patients undergoing conventional open surgery. At a mean follow-up duration of 15.9 months, no cases of recurrence were reported.

Robotic transoral and retroauricular approach

Tae *et al.* described four cases in which a combined transoral and retroauricular robotic approach was utilized. This approach was necessitated by the inability of the transoral route alone to provide adequate access to level II lymph nodes. Consequently, the robotic retroauricular approach was employed for level II dissections, while levels III–V were addressed using the transoral approach. For the combined procedure, the average operative time was 431 minutes. The mean numbers of total and positive lymph nodes removed from the lateral compartment were 38.3 and 8.3, respectively (51).

Limitations of the study

The available data on these procedures are limited and scattered across various techniques, making it challenging to consolidate findings into a comprehensive analysis. Furthermore, these complex procedures are primarily performed in high-volume centers by surgeons with specialized expertise, limiting their generalizability to less experienced facilities. Additionally, insufficient long-term data to evaluate oncological outcomes leaves uncertainties about their effectiveness over time. Potential bias also exists, as the results largely reflect outcomes from specialized centers, which may not represent typical results in lower-volume settings. These limitations highlight the need for a cautious interpretation of the findings and emphasize the importance of further research involving larger patient cohorts and extended follow-up to address these gaps.

Conclusions

Remote-access endoscopic and robotic LND is a feasible and safe surgical option for carefully selected patients. This technique yields excellent postoperative cosmetic outcomes while demonstrating comparable results to conventional LND in terms of lymph node yield, complication rates, and recurrence rates. However, the approach is associated with certain limitations, including prolonged operative times, higher procedural costs, and technical challenges. Further research with extended follow-up periods is necessary to evaluate and define the long-term surgical and oncologic outcomes.

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Footnote

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References

1. Li Y, Che W, Yu Z, et al. The Incidence Trend of Papillary Thyroid Carcinoma in the United States During 2003-2017. Cancer Control 2022;29:10732748221135447.
2. Feng JW, Qin AC, Ye J, et al. Predictive Factors for Lateral Lymph Node Metastasis and Skip Metastasis in Papillary Thyroid Carcinoma. Endocr Pathol 2020;31:67-76.
3. Haugen BR, Alexander EK, Bible KC, et al. 2015 American Thyroid Association Management Guidelines for Adult Patients with Thyroid Nodules and Differentiated Thyroid Cancer: The American Thyroid Association Guidelines Task Force on Thyroid Nodules and Differentiated Thyroid Cancer. Thyroid 2016;26:1-133.
4. Haddad RI, Bischoff L, Ball D, et al. Thyroid Carcinoma, Version 2.2022, NCCN Clinical Practice Guidelines in Oncology. J Natl Compr Canc Netw 2022;20:925-951.
5. Long B, Luo M, Zhou K, et al. Risk factors and distribution pattern of lateral lymph node recurrence after central neck dissection for cN1a papillary thyroid carcinoma. BMC Surg 2024;24:270.
6. Zhao L, Wu F, Zhou T, et al. Risk factors of skip lateral cervical lymph node metastasis in papillary thyroid carcinoma: a systematic review and meta-analysis. Endocrine 2022;75:351-9.
7. Zhang Y, Ji X, Zhang X, et al. Risk factors for cervical lymph node metastasis at different lateral levels in papillary thyroid cancer: level III as the central hub. Gland Surg 2024;13:1921-30.
8. Keum HS, Ji YB, Kim JM, et al. Optimal surgical extent of lateral and central neck dissection for papillary thyroid carcinoma located in one lobe with clinical lateral lymph node metastasis. World J Surg Oncol 2012;10:221.
9. Song CM, Ji YB, Kim IS, et al. Low transverse incision for lateral neck dissection in patients with papillary thyroid cancer: improved cosmesis. World J Surg Oncol 2017;15:97.
10. Nguyen VC, Song CM, Ji YB, et al. Feasibility of remote-access and minimally invasive video-assisted approaches in lateral neck dissection for papillary thyroid carcinoma: A systematic review and network meta-analysis. Eur J Surg Oncol 2024;50:108469.
11. Tae K, Ji YB, Song CM, et al. Robotic and Endoscopic Thyroid Surgery: Evolution and Advances. Clin Exp Otorhinolaryngol 2019;12:1-11.
12. Paek SH, Kang KH. Robotic thyroidectomy and cervical neck dissection for thyroid cancer. Gland Surg 2016;5:342-51.
13. Tan Y, Guo B, Deng X, et al. Transoral endoscopic selective lateral neck dissection for papillary thyroid carcinoma: a pilot study. Surg Endosc 2020;34:5274-82.
14. Shimizu K, Kitagawa W, Akasu H, et al. 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;77:217-20.
15. Kitagawa W, Shimizu K, Akasu H, et al. Endoscopic neck surgery with lymph node dissection for papillary carcinoma of the thyroid using a totally gasless anterior neck skin lifting method. J Am Coll Surg 2003;196:990-4.
16. Lin P, Liang F, Cai Q, et al. Comparative study of gasless endoscopic selective lateral neck dissection via the anterior chest approach versus conventional open surgery for papillary thyroid carcinoma. Surg Endosc 2021;35:693-701.
17. Ohgami M, Ishii S, Arisawa Y, et al. Scarless endoscopic thyroidectomy: breast approach for better cosmesis. Surg

Laparosc Endosc Percutan Tech 2000;10:1-4.
18. Bärlehner E, Benhidjeb T. Cervical scarless endoscopic thyroidectomy: Axillo-bilateral-breast approach (ABBA). Surg Endosc 2008;22:154-7.
19. Zhao W, Wang B, Yan S, et al. Minilaparoscopy-Assisted Modified Neck Dissection Through Bilateral Breast Approach. VideoEndocrinology 2016;3:ve.2015.0038.
20. Li Z, Wang P, Wang Y, et al. Endoscopic lateral neck dissection via breast approach for papillary thyroid carcinoma: a preliminary report. Surg Endosc 2011;25:890-6.
21. Yan H, Wang Y, Wang P, et al. "Scarless" (in the neck) endoscopic thyroidectomy (SET) with ipsilateral levels II, III, and IV dissection via breast approach for papillary thyroid carcinoma: a preliminary report. Surg Endosc 2015;29:2158-63.
22. Wang B, Weng YJ, Wang SS, et al. Feasibility and safety of needle-assisted endoscopic thyroidectomy with lateral neck dissection for papillary thyroid carcinoma: a preliminary experience. Head Neck 2019;41:2367-75.
23. Qu R, Hu X, Guo Y, et al. Endoscopic Lateral Neck Dissection (IIA, IIB, III, and IV) Using a Breast Approach: Outcomes From a Series of the First 24 Cases. Surg Laparosc Endosc Percutan Tech 2020;31:66-70.
24. Yan HC, Xiang C, Wang Y, et al. Scarless endoscopic thyroidectomy (SET) lateral neck dissection for papillary thyroid carcinoma through breast approach: 10 years of experience. Surg Endosc 2021;35:3540-6.
25. Chen ZX, Song YM, Chen JB, et al. Qin's seven steps for endoscopic selective lateral neck dissection via the chest approach in patients with papillary thyroid cancer: experience of 35 cases. Surg Endosc 2022;36:2524-31.
26. Ikeda Y, Takami H, Sasaki Y, et al. Endoscopic neck surgery by the axillary approach. J Am Coll Surg 2000;191:336-40.
27. Yoon JH, Park CH, Chung WY. Gasless endoscopic thyroidectomy via an axillary approach: experience of 30 cases. Surg Laparosc Endosc Percutan Tech 2006;16:226-31.
28. Kang SW, Lee SC, Lee SH, et al. Robotic thyroid surgery using a gasless, transaxillary approach and the da Vinci S system: the operative outcomes of 338 consecutive patients. Surgery 2009;146:1048-55.
29. Kang SW, Lee SH, Ryu HR, et al. Initial experience with robot-assisted modified radical neck dissection for the management of thyroid carcinoma with lateral neck node metastasis. Surgery 2010;148:1214-21.
30. Kang SW, Lee SH, Park JH, 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.
31. Lee J, Kwon IS, Bae EH, et al. Comparative analysis of oncological outcomes and quality of life after robotic versus conventional open thyroidectomy with modified radical neck dissection in patients with papillary thyroid carcinoma and lateral neck node metastases. J Clin Endocrinol Metab 2013;98:2701-8.
32. Tae K, Ji YB, Song CM, et al. Robotic lateral neck dissection by a gasless unilateral axillobreast approach for differentiated thyroid carcinoma: our early experience. Surg Laparosc Endosc Percutan Tech 2014;24:e128-32.
33. Song CM, Park JS, Park W, et al. Feasibility of Charcoal Tattooing for Localization of Metastatic Lymph Nodes in Robotic Selective Neck Dissection for Papillary Thyroid Carcinoma. Ann Surg Oncol 2015;22 Suppl 3:S669-75.
34. Song CM, Ji YB, Sung ES, et al. Comparison of Robotic versus Conventional Selective Neck Dissection and Total Thyroidectomy for Papillary Thyroid Carcinoma. Otolaryngol Head Neck Surg 2016;154:1005-13.
35. Kim JK, Lee CR, Kang SW, et al. Robotic transaxillary lateral neck dissection for thyroid cancer: learning experience from 500 cases. Surg Endosc 2022;36:2436-44.
36. Ho J, Kim D, Lee JE, et al. Single-Port Transaxillary Robotic Modified Radical Neck Dissection (STAR-RND): Initial Experiences. Laryngoscope 2023;133:709-14.
37. Choe JH, Kim SW, Chung KW, et al. Endoscopic thyroidectomy using a new bilateral axillo-breast approach. World J Surg 2007;31:601-6.
38. Seup Kim B, Kang KH, Park SJ. Robotic modified radical neck dissection by bilateral axillary breast approach for papillary thyroid carcinoma with lateral neck metastasis. Head Neck 2015;37:37-45.
39. Yu HW, Chai YJ, Kim SJ, et al. Robotic-assisted modified radical neck dissection using a bilateral axillo-breast approach (robotic BABA MRND) for papillary thyroid carcinoma with lateral lymph node metastasis. Surg Endosc 2018;32:2322-7.
40. Paek SH, Lee HA, Kwon H, et al. Comparison of robot-assisted modified radical neck dissection using a bilateral axillary breast approach with a conventional open procedure after propensity score matching. Surg Endosc 2020;34:622-7.
41. He Q, Zhu J, Zhuang D, et al. Robotic lateral cervical lymph node dissection via bilateral axillo-breast approach for papillary thyroid carcinoma: a single-center experience

of 260 cases. J Robot Surg 2020;14:317-23.
42. Song RY, Sohn HJ, Paek SH, et al. The First Report of Robotic Bilateral Modified Radical Neck Dissection Through the Bilateral Axillo-breast Approach for Papillary Thyroid Carcinoma With Bilateral Lateral Neck Metastasis. Surg Laparosc Endosc Percutan Tech 2020;30:e18-22.
43. Choi YS, Hong YT, Yi JW. Initial Experience With Robotic Modified Radical Neck Dissection Using the da Vinci Xi System Through the Bilateral Axillo-Breast Approach. Clin Exp Otorhinolaryngol 2021;14:137-44.
44. Choi JY, Kang KH. Robotic modified radical neck dissection with bilateral axillo-breast approach. Gland Surg 2017;6:243-9.
45. Terris DJ, Singer MC, Seybt MW. Robotic facelift thyroidectomy: patient selection and technical considerations. Surg Laparosc Endosc Percutan Tech 2011;21:237-42.
46. Byeon HK, Holsinger FC, Tufano RP, et al. Robotic total thyroidectomy with modified radical neck dissection via unilateral retroauricular approach. Ann Surg Oncol 2014;21:3872-5.
47. Lira RB, Chulam TC, Kowalski LP. Variations and results of retroauricular robotic thyroid surgery associated or not with neck dissection. Gland Surg 2018;7:S42-52.
48. Nguyen VC, Song CM, Ji YB, et al. Evaluation of the validity and reliability of a self-assessment questionnaire for cosmetic outcomes after thyroidectomy: a cross-sectional validation study. Eur Arch Otorhinolaryngol 2024;281:1505-13.
49. Tae K, Kim KH. Transoral robotic selective neck dissection for papillary thyroid carcinoma: Dissection of Levels III and IV. Head Neck 2020;42:3084-8.
50. Ngo DQ, Tran TD, Le DT, et al. Transoral Endoscopic Modified Radical Neck Dissection for Papillary Thyroid Carcinoma. Ann Surg Oncol 2021;28:2766.
51. Tae K, Choi HW, Ji YB, et al. Feasibility of transoral robotic selective neck dissection with or without a postauricular incision for papillary thyroid carcinoma: A pilot study. Front Surg 2022;9:985097.
52. Van Le Q, Ngo DQ, Le DT, et al. ASO Author Reflections: A New Procedure for Modified Radical Neck Dissection via the Transoral Endoscopic Approach. Ann Surg Oncol 2021;28:2767.
53. Kuang P, Wang Y, Wu G, et al. Endoscopic lateral neck dissection via the breast and transoral approaches for papillary thyroid carcinoma: A preliminary report. Front Surg 2022;9:997819.
54. Chen ZX, Chen JB, Pang FS, et al. A novel hybrid approach for "Scarless" (at the neck) lateral neck dissection for papillary thyroid carcinoma: A case series and literature review. Front Oncol 2022;12:985761.
55. Wang Y, Luo Y, Wu G, et al. Wu's seven steps for endoscopic central and lateral neck dissection via breast combined with oral approach for papillary thyroid cancer. Surg Endosc 2023;37:5380-7.
56. Zhou S, Wu P, Li W, et al. Challenging routine: technical difficulties and solutions of endoscopic thyroidectomy via a combined transoral and breast approach - a case-series and learning curve. Int J Surg 2023;109:3273-82.
57. Kim WS, Koh YW, Byeon HK, et al. Robot-assisted neck dissection via a transaxillary and retroauricular approach versus a conventional transcervical approach in papillary thyroid cancer with cervical lymph node metastases. J Laparoendosc Adv Surg Tech A 2014;24:367-72.

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