



All roads lead to the thyroid gland: review of two popular “scarless” thyroidectomy approaches

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Abstract: Thyroidectomy is the most common procedure performed in endocrine surgery. The standard surgical approach is via the anterior neck using a Kocher incision. Over the past two decades, minimally invasive and remote endoscopic approaches to thyroid surgery have emerged as surgeons attempt to improve the cosmesis of the surgery and move towards “scarless” approaches. Remote access techniques utilize strategically hidden incisions removed from the highly visible anterior neck. Rapidly emerging data shows these have comparable outcomes to the conventional open approach and result in high patient satisfaction and improved quality of life in thyroidectomy patients. The transoral endoscopic vestibular approach (TOETVA) and the robotic bilateral axillo-breast approach (BABA) are the two most common remote access approaches to date. In TOETVA, three incisions within the vestibular mucosa are used to access the thyroid. The use of standard laparoscopic instruments and a slightly less steep learning curve compared to other techniques have led to a successful adoption in North America. The robotic BABA technique uses 4 small, widely spaced incisions to provide ideal triangulation of instruments with a familiar midline view of the thyroid. Due to the robotic platform, it has a steeper learning curve but has seen great success in Asia. This article will review these two techniques, offering a comparison and highlighting the clinical trend and future implications.

Keywords: Scarless thyroidectomy; transoral endoscopic thyroidectomy; bilateral axillo-breast approach robotic thyroidectomy (BABA robotic thyroidectomy)

Received: 26 May 2020; Accepted: 29 April 2021; Published: 30 June 2021.

doi: 10.21037/aot-20-47

View this article at: <http://dx.doi.org/10.21037/aot-20-47>

Introduction

Thyroidectomy is the most common procedure performed in endocrine surgery. Thyroid surgery has evolved dramatically from its original inception in 1906 by Theodore Kocher. The last 20 years have shown an increased trend towards remote access endoscopic and,

more recently, robotic techniques (1). This is driven by evidence which shows that quality of life in post thyroidectomy patients is significantly affected by the mere presence of a visible cervical scar (2,3).

A variety of different remote access approaches have been developed, primarily in Asia where there is great cultural stigma associated with anterior neck scar. These

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utilize incisions in the axilla, periareolar area of the breast, retroauricular area and vestibular mucosa. Despite great success seen in the East, the adoption has been slower in North America due to various cultural, regulatory, and fiscal system differences. However, as more data emerges showing comparable outcomes to conventional open thyroidectomy, plus increased patient satisfaction and demand, enthusiasm amongst surgeons is growing.

The transoral endoscopic vestibular approach (TOETVA) and the robotic bilateral axillo-breast approach (BABA) are the two most common remote access approaches to date. This article will review these two techniques, offering a comparison and highlighting the clinical trend and future implications.

TOETVA

TOETVA is the most commonly performed variation of transoral endoscopic thyroidectomy. Although some consider TOETVA as a “natural orifice transluminal endoscopic surgery,” the approach doesn’t involve the oral cavity nor the luminal section of the aerodigestive system. The current TOETVA technique was first described in a cadaveric series by Richmon in 2011 (4). Six years later, Anuwong in Bangkok, Thailand published the first human large series of 60 patients (5). Since that initial sentinel publication in 2016 there has been a growing interest in the technique and increasing efforts to establish it here in the US. Chronologically, TOETVA is the last of the remote access techniques to emerge but, unlike the majority of its predecessors, the general consensus seems to be, as Dr. Yeh put it in a *JAMA Surg* commentary article to Dr. Anuwong’s initial data, that this one “just might have legs” (6).

The basic principles of the TOETVA operation, when taken at face value, certainly seem more feasible than other described techniques which entail use of the robotic platform or require extensive flap dissection to approach the thyroid from an unfamiliar and oftentimes unnatural angle. Here, the flap dissection plane is similar to that of open thyroidectomy and a basic laparoscopic set up is employed. The reported learning curve of 7–11 cases is not overwhelming (7-9). Finally, and perhaps most convincing of all, is that fact that this technique alone, with its use of 3 rapidly healing inner lip mucosal incisions, is truly scarless.

The adaptation of this technique in North America has been relatively steady but is not yet widely disseminated. The first consecutive series of cases performed in the US was reported by Udelsman *et al.* at Yale University in 2016

followed by Inabnet *et al.* at Mount Sinai Beth Israel (10,11). Since then, a growing body of experience has more firmly established a comparable safety profile to that of open thyroidectomy for appropriately selected patients, with few drawbacks other than increased operative time (12). Many institutional and surgical society sponsored workshops have been attempted to aid in the promotion of the technique.

BABA

The BABA endoscopic thyroidectomy, developed in 2004 at Seoul National University Hospital in South Korea, is a remote access technique that uses 4 small, widely spaced incisions to provide ideal triangulation of instruments with a familiar midline view of the thyroid (13) (*Figure 1*). While initially developed using standard laparoscopy, the technique quickly adapted a robotic platform keeping in trend with the high-volume scarless thyroid centers in Asia (14). This addition allowed for greater dexterity and surgeon autonomy, given the use of the fourth arm, in a challenging working space.

While the BABA thyroidectomy is well established in Asia, it remains rare here in the United States. Despite preceding Anuwong’s TOETVA, the robotic BABA has been slower to find its place in North America, likely due to the robotic platform and the relatively steeper learning curve of 35–40 cases that accompanies this technology (9,14). Nevertheless, the safety profile has been well-established in Asia and the first series of 142 cases performed in the United States was recently submitted for publication. This outcomes based study shows that the robotic BABA technique is applicable to the US patient population with similarly excellent results and low rate of both standard and technique-specific complications (unpublished institutional data).

After the challenges encountered with the robotic transaxillary thyroidectomy (RTT), many experienced endocrine surgeons seem to be wary of robotic thyroidectomies and its progress is further hampered by the fact that there are no U.S. Food and Drug Administration (FDA) approved robotic devices at this time. However, the BABA technique, with its familiar midline view and widely spaced incisions, is more compatible with the robotic platform than that of the crowded unilateral trocar positioning required by the robotic transaxillary approach and is more adaptable for various benign and malignant thyroid disease. Its cosmetic outcome is excellent with high patient satisfaction reported (13,15). While

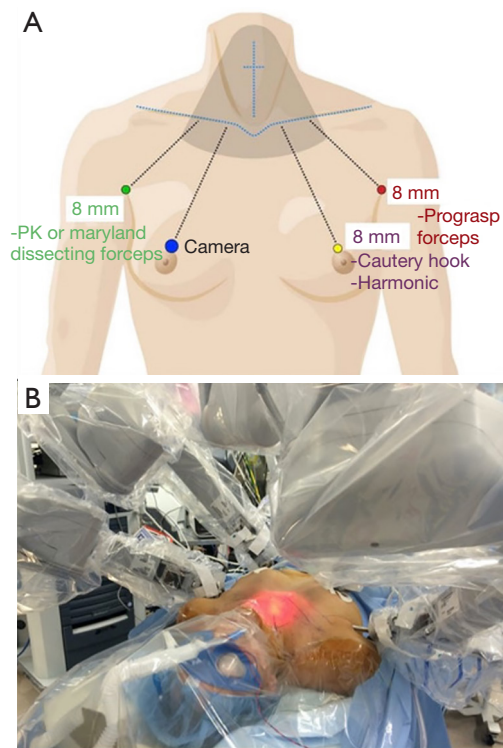


Figure 1 BABA set up and triangulation. (A) Incision/trocar sites and typical robotic instrument set up. Triangular shade represents potential subplatysmal flap area which will depend on the thyroid pathology. (B) Illustration of patient positioning, drape set up, and docking of the robotic arms. BABA, bilateral axillo-breast approach.

it cannot technically be called “scarless,” when healed the 4 strategically placed incisions are nearly invisible. Furthermore, these incisions heal well even in those patients with a history of keloids or hypertrophic scars.

Surgical indications, contraindications and outcomes

Patient selection

A vital step when attempting to implement a novel surgical technique is that of inclusion criteria and patient candidacy. There is some variability amongst authors but the inclusion criteria for TOETVA are relatively well-established with little variation since Anuwong’s 2016 report of the first 60 human cases. These include the following in a thyroid gland ≤ 10 cm in size: (I) FNA-proven benign and indeterminate thyroid nodules < 6 cm, (II) benign disease

(goiter, toxic nodule), (III) well-controlled Grave’s disease, (IV) well-differentiated T1 thyroid carcinoma (≤ 2 cm) without evidence of extrathyroidal extension or central/lateral compartment spread, and (V) grade I substernal goiters (no extension below the clavicle). Contraindications include previous neck surgery, history of head/neck radiation, chin or mandibular surgery/implants, active oral cavity infections or cancer as well as patients unfit for surgery or who cannot tolerate anesthesia (5,16-18).

The initial indications for endoscopic BABA were similar to those of TOETVA. However, these have expanded with many years of experience and the robotic adaptation. These include all of the TOETVA indications with the addition of well-differentiated carcinoma (DTC) up to 4 cm in size and thyroid nodules up to 8–10 cm in size. Here, preoperative evidence of central neck or lateral neck metastasis is not a contraindication as both areas are easily reached via this approach. Additionally, the first series of cases in North America pushes the boundaries even further by showing the feasibility of robotic BABA even in the face of larger more locally advanced (i.e., strap muscle invasion) primary cancers. Absolute contraindications include large goiters with a significant substernal component, locally invasive cancer cases beyond strap muscle involvement, patients with active breast cancer issues, or females who are actively breastfeeding (19,20).

Outcomes

At this time, both approaches have proven safety profiles comparable to that of open thyroidectomy with minimal approach specific complications (e.g., flap seroma, wound infection) (12,19,21,22). These results are extrapolated primarily from a systematic review by Camenzuli *et al.* (23). This study evaluated all eligible reports of transoral endoscopic surgery (robotic variation was excluded) from 2011 to 2018 for a cumulative total of 785 patients (23). For the robotic BABA approach these results were taken primarily from the largest single institution series of 1,026 patients by Lee *et al.* at Seoul National University Hospital in South Korea (19). The reported complication rates from both studies are shown in *Table 1*. For open thyroidectomy the reported rates of transient and permanent hypoparathyroidism are 6.9–46% and up to 12.1%, respectively while those of transient and permanent RLN palsy are 0.4–12% and 5–6%, respectively (24-26). The incidences of these complications for both novel techniques are well within these ranges. The complication

Table 1 Complication comparison

Complications	TOETVA (%) (n=785)	BABA (%) (n=1,026)
Thyroid surgery		
Hypoparathyroidism		
Transient	7.4	39.1
Permanent	0	1.5
RLN palsy		
Transient	4.3	14.2
Permanent	0.1	0.2
Bleeding	0.1	0.2
Remote access		
Transient neuropraxia		
Mental nerve	2.3	n/a
Chest wall	n/a	41.2
Flap seroma	2.8	NR, *drains routinely left
Open conversion	1.3	0
Infection	1.4	NR

*, NR, not recorded; n/a, not applicable.

rates are noticeably higher for BABA in all categories listed but several factors should be taken into consideration. In the BABA study 872/1,026 (85%) patients underwent total thyroidectomy with ipsilateral prophylactic central lymph node dissection while only 262/785 (33%) of the patients across the 16 included TEOTVA studies underwent total thyroidectomy with a very small percentage of those undergoing concomitant central neck dissection (19,23). The results from these TOETVA and BABA studies were from a small group of expert thyroid surgeons with extensive experience in these advanced novel techniques and likely cannot be generalized.

In any remote-access surgery there is always a chance for an open conversion due to poor visualization, difficulties with hemostasis, or intraoperative complications (*Table 1*). Although the incidence is low, open conversion should be discussed with patients for optimal safety and outcome. Lee *et al.* had a 0% open conversion rate in their robotic series (19). However in the initial report of endoscopic BABA from this institution there was a 2.9% incidence of open conversion (13). In the first reported series of 142 cases of robotic BABA in

the US, the incidence of open conversion was 2.8%. This is likely attributed to larger average tumor size, higher percentage of Grave's patients and higher percentage of thyroiditis on final pathology. Additionally, the rates of hypoparathyroidism and RLN palsy were significantly lower in the US study where prophylactic central neck dissections are rarely performed. These rates were 6% and 0.7% for temporary and permanent hypoparathyroidism, respectively and 1.4% and 0.7% for temporary and permanent vocal cord palsy, respectively.

Cosmesis does not come without a price. New approach-specific complications accompany these novel surgical techniques due to the dissection planes necessary to access the thyroid gland (*Table 1*). For TOETVA, the thyroid is accessed through the oral mucosa and so is considered a clean contaminated surgery. Additionally, the surgeon must be vigilant to avoid thermal injury and tears to the fragile skin of the face and neck as well as oral commissure tears. For BABA, seroma is a risk given the large chest wall flap. Tracheal injury and esophageal perforation have also been reported (27). Both BABA and TOETVA, can have flap related complications including flap skin numbness and paresthesia. With TOETVA, the mental nerve is at risk during trocar placement. This injury produces numbness, tingling and burning of the chin and lips that can persist for several weeks to beyond 6 months. With the modification of trocar placement and a renewed understanding of variation in mental nerve anatomy, incidence and severity of this particular complication have decreased (8,22). Given the relatively more extensive flap dissection required of the BABA approach patients do often experience chest wall neuropraxia in the immediate postoperative period. Retrospectively the Korean group out of Seoul National University Hospital noticed that this seemed to improve after a 3-month period (28,29). The group prospectively studied this, using 3 objective measures of chest wall sensation, in a small group of patients and found that the chest wall sensory changes experienced at 1 month post operatively normalized by the 3-month mark (30).

Another rare but feared complication that can be seen with the transoral approach is carbon dioxide air embolism related to initial insufflation in setting of vessel injuries during blunt dissection for the flap. The overall reported incidence of this complication is 0.6% (N=5) (23).

Pros/cons

These two approaches are entirely distinct surgical entities

and a direct comparison is not an easy feat. Assessing their advantages and limitations requires a comprehensive understanding of the mechanics of each approach as well as knowledge of the overall goals of remote access surgery (Table 2). In minimally invasive surgery, technical ability is limited by the mechanics of the instruments, surgical platform and the approach design. As shown in Table 2, the only overlap here is a common midline view of the thyroid gland. This is useful as it allows for bilateral surgery, something that is lacking in other approaches such as the transaxillary and retroauricular approaches.

TOETVA's more limited flap space and dissection plane can be considered less invasive and more in line with the

principles of minimally invasive surgery. The tradeoff to this is that trocar placement is limited by the width of the patient's lips (facial anthropometric dimensions). Such spatial limitation results in a narrow parallel approach angle and less than ideal instrument triangulation and camera visibility (Figure 2). These limitations are augmented by the use of the laparoscopic instruments which are fulcrum and leverage based leading to instrument collisions. Furthermore, despite the midline view of the thyroid, TOETVA dissection proceeds in an unfamiliar cranial to caudal manner with the recurrent laryngeal nerve identified and traced from its insertion at the cricothyroid muscle (Figure 3). However, most endocrine surgeons are facile with laparoscopic instruments which helps with the learning curve and maneuverability after certain adjustments.

Similar to BABA, the robotic platform has recently been applied to the transoral technique. The transoral robotic thyroidectomy (TORT) is a relatively new application, the first case series of 4 patients was reported in 2015, but it is gaining in popularity largely driven by Dr. Hoon Yub Kim of South Korea (31,32). The articulating instruments are particularly advantageous given the spatial limitations of trocar placement, although a fourth trocar is introduced in the axilla (33).

BABA requires a larger and more time-consuming flap creation, but the payoff is an increased working space which allows for an additional fourth working arm, ideal triangulation of instruments. The midline view here is more familiar to that of conventional open surgery allowing for a nearly identical dissection, including nerve identification

Table 2 Approach-specific comparison

Variables	TOETVA	BABA
Bilateral approach	X	X
Less invasive	X	
More hidden scar	X	
Familiar view		X
Triangulation		X
# of instruments		X
Maneuverability		X
Lateral neck dissection		X

TOETVA, transoral endoscopic vestibular approach; BABA, bilateral axillo-breast approach.

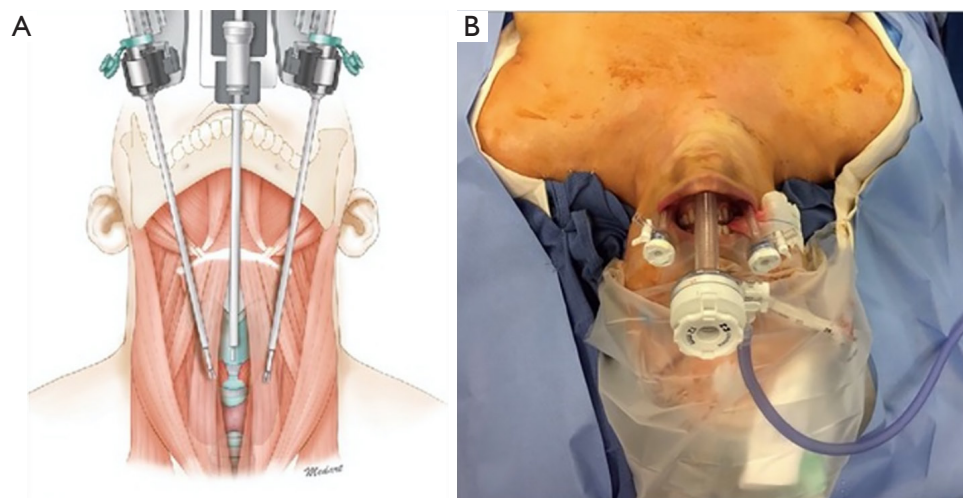


Figure 2 Transoral approach set up and triangulation. (A) Illustration of TORT trocar placement. (B) Illustration of TOETVA trocar placement and patient positioning. TORT, transoral robotic thyroidectomy; TOETVA, transoral endoscopic vestibular approach.

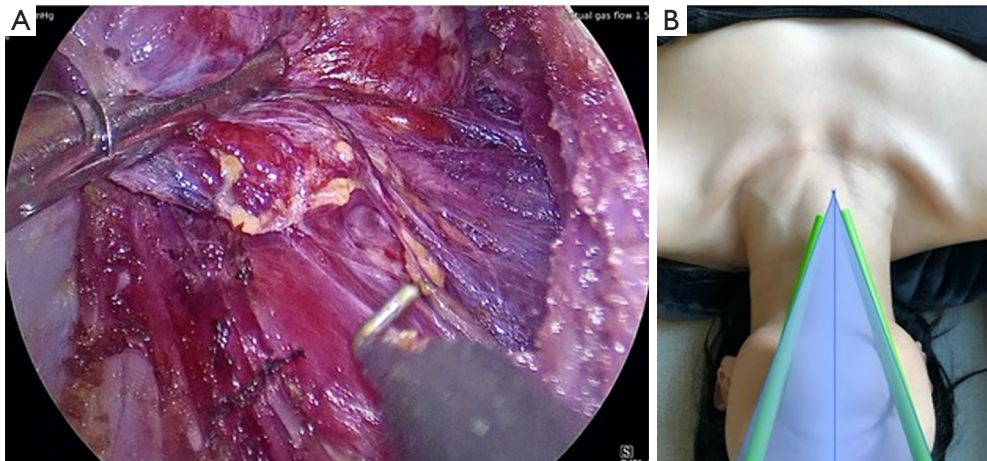


Figure 3 TOETVA cranial to caudal approach to dissection. (A) “Top down” Intraoperative view of the surgical field with the right thyroid gland retracted medially. (B) Demonstration of biomechanics of TOETVA triangulation and approach angle. TOETVA, transoral endoscopic vestibular approach.

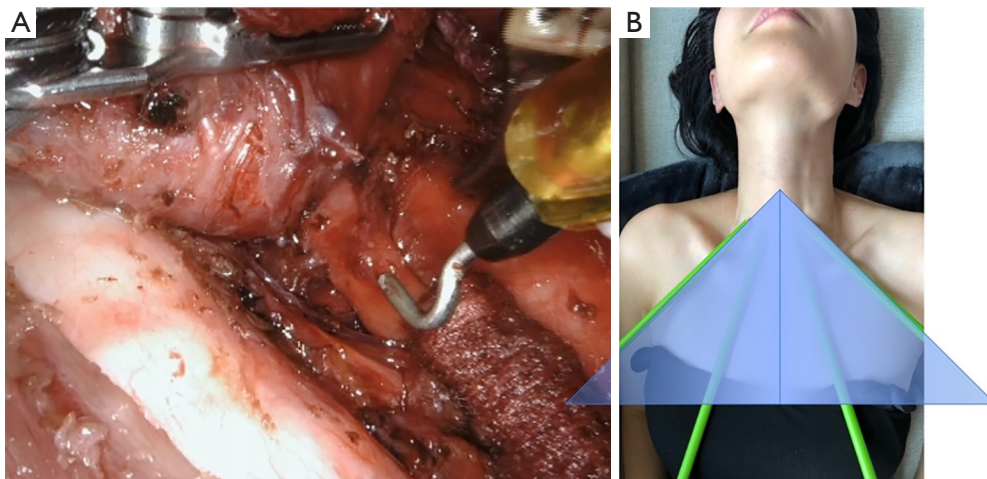


Figure 4 BABA caudal to cranial approach to dissection. (A) “Bottom up” Intraoperative view of the surgical field with the left thyroid gland retracted medially. (B) Demonstration of biomechanics of BABA triangulation and approach angle. BABA, bilateral axillo-breast approach.

and tracing (27) (*Figure 4*). The use of the robotic platform does come with an increased cost, longer operating time, need for trained robotic OR team, and steeper learning curve, but the articulating instruments and superior views allow for an operative approach that more closely mimics the finesse of an open thyroidectomy.

Robotic BABA expands the application of remote access thyroidectomy for cancer patients. The larger flap and wider working space coupled with the robot’s articulating instruments make endoscopic central and lateral neck dissections feasible, something that is made much harder

with TOETVA’s laparoscopic instruments and narrow working space (34-37). Several studies have demonstrated the efficacy of robotic modified radical neck dissections using the BABA approach in patients with advanced papillary thyroid cancer with lateral neck spread, including bilateral neck involvement. All demonstrated outcomes comparable to open neck dissection (35-37). Additionally, BABA’s more forgiving axillary fold extraction site allows for removal of larger cancer specimens without risk of capsular disruption (20). The role of TOETVA for thyroid cancer beyond papillary microcarcinoma is still unclear (38). At

present, the technique is recommended for DTC <2 cm in size without clinically positive nodes or extrathyroidal extension (18,39). A major limitation here is the vestibular extraction site. The presence of a rigid mental protuberance, mentalis muscle and the small vestibular mucosal incisions limits the specimen removal for tumors larger than 2 cm (16,40). A variation of the TORT developed by Dr. Kim of South Korea places the fourth arm in the right axilla to be used for countertraction during the case. This can then be used as the extraction site, which is especially useful for larger specimens (33). The midline approach does lend itself to central neck dissection and this has been described in the literature. Yet, its application at this time is limited to prophylactic central neck dissection, a practice that is largely going to the wayside with the more conservative 2015 ATA guidelines, and intraoperatively discovered nodal disease (16,41). A recent paper by Grogan *et al.* examined what percentage of US thyroidectomy patients would be eligible for TOETVA, based on standardized inclusion criteria. The indications were benign disease, indeterminate cytology and cancer. The latter had the lowest percentage eligibility at 29% while 69% and 76% of benign disease and indeterminate nodules, respectively, were eligible (42).

When evaluating oncological safety of thyroidectomy, serum thyroglobulin (Tg) level and radioiodine uptake on whole body scan are common parameters to assess surgical completeness. Given the high prevalence of small differentiated thyroid cancer in Asia, the use of BABA in DTC has been well-studied by the group from Seoul National Hospital in South Korea. Their data repeatedly show that outcomes are comparable to conventional open surgery for small DTC (19,27,43). In 2017, they published data for larger cancers, 2–4 cm in size, and found equally favorable results (20). For this study, the median follow up period was 40.2 months. TOETVA, as a more recently described technique, is in an earlier state of investigation for malignant cases. Additionally, TOETVA is more often performed for indeterminate nodules, or more recently, small DTC in low risk patients for which lobectomy, rather than total thyroidectomy, is preferred (44). As TOETVA becomes more popularized worldwide its use is being broadened and efforts to show its oncological safety are emerging. Recently, Ahn and Yi published a series of 150 patients who underwent TOETVA for thyroid cancer, however only 40 patients had total thyroidectomy. Regardless this is the largest series to date of TOETVA for thyroid cancer which evaluates surgical completeness. Both number of central lymph nodes harvested and Tg levels

were comparable to open thyroidectomy and the median follow up period was 105 days (45).

Discussion

We have described two of the more popular and well-studied remote access techniques to date. These are two very distinct surgical approaches to thyroidectomy but share the same goal: to safely remove the thyroid with the smallest possible footprint without compromising surgical excellence.

These advanced techniques should be performed by high volume thyroid surgeons (17). An intimate understanding of the central neck anatomy is crucial to safe execution of a remote access approach. A background in laparoscopic surgery and knowledge of the general principles of minimally invasive surgery are also important. BABA can be performed endoscopically but is well-suited to the robotic platform which has greatly advanced the approach. If the surgeon wishes to pursue this technique, robotic credentialing and proficiency are essential. For some, TOETVA may seem a more realistic undertaking given the shorter learning curve and use of standard laparoscopic instruments. Those with a strong robotic background may wish to pursue robotic BABA given its potential for use in more advanced thyroid disease.

These are high specialized techniques and the data reported in this review are from a select few expert high-volume surgeons who have long passed the initial learning curves. Therefore, these favorable results are not generalizable. There is a paucity of data on the results of this approaches by novice surgeons, but one must assume that conversion and complication rates would be higher. For those serious about pursuing these techniques it is of the utmost importance to attain sufficient training and be proctored by a surgeon experienced in this technique for the first several cases.

For those new to remote access thyroidectomy, it is advisable to select one approach and master it rather than trying to learn two distinct, highly specialized techniques simultaneously. Which approach one selects is a matter of preference depending on the individual surgeon, their training experience, and the institutional support system. At this time, there is limited data regarding the use of TOETVA for more advanced malignant pathology while the robotic BABA technique and its large and readily extensible working area lend itself to more advanced pathology, both benign and malignant.

As the experience and the dissemination of these techniques grow over time, disease specific algorithms and indications should be established based on the outcome and innate limitations of each techniques.

At this time, more long-term data is needed to assess overall efficacy, particularly for the treatment of malignant disease. However, regardless of the approach, with appropriate patient selections combined with surgeon's innovative spirit and determination, these techniques will continue to evolve with excellent surgical outcomes.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the Guest Editors (Jonathon Russell and Jeremy Richmon) for the series "The Management of Thyroid Tumors in 2021 and Beyond" published in *Annals of Thyroid*. The article has undergone external peer review.

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at <http://dx.doi.org/10.21037/aot-20-47>). The series "The Management of Thyroid Tumors in 2021 and Beyond" was commissioned by the editorial office without any funding or sponsorship. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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doi: 10.21037/aot-20-47

Cite this article as: Mencio M, Fernandez-Ranvier G, Inabnet WB, Suh H. All roads lead to the thyroid gland: review of two popular “scarless” thyroidectomy approaches. *Ann Thyroid* 2021;6:10.