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ADVANCES IN SURGERY

Transoral Endoscopic Thyroidectomy Vestibular Approach

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Keywords

• Transoral thyroidectomy • Endoscopic thyroidectomy • Transoral neck surgery • Natural orifice thyroidectomy • NOTES • TOETVA

Key points

- Aesthetic concerns regarding anterior neck incisions have driven innovation to develop alternative access to the thyroid gland.
- Transoral endoscopic thyroidectomy vestibular approach (TOETVA) is a safe and effective alternative approach to thyroidectomy.
- TOETVA maximizes minimally invasive principles compared with other remote access approaches.
- Adoption of this method requires meticulous preparation and patient selection.

INTRODUCTION

Transcervical thyroidectomy, as refined by Theodor Kocher, has been the standard operative approach since his landmark work more than one hundred years ago. Although surgical and anesthetic techniques have evolved, the transcervical approach has endured. Mirroring other surgical procedures, the last 2 decades brought forth a debate regarding minimally invasive neck surgery to diminish or eliminate anterior cervical collar incisions. This cosmetic concern is most prominent in Asian countries where an anterior neck scar is considered a violation of aesthetics, especially among young female patients. The concern

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led to the development of multiple remote access approaches for thyroidectomy, including transaxillary, transbreast, and retroauricular routes. Each of these is associated with unique difficulties, risks, and complications, including the potential for significant nerve and vascular injuries. More recently, a technique was developed that eliminates external scarring, using a natural orifice transluminal endoscopic surgical (NOTES) approach.

EVOLUTION OF THYROID SURGERY

Thyroidectomy was first described more than 1000 years ago; however, until relatively recently, the high morbidity limited extensive application [1–3]. Morbidity was so profound that operative outcomes led to the imprisonment of a surgeon in 1646, and the French Academy of Medicine enacted a total ban of the operation in 1850 [2]. In 1866 in the United States, Samuel Gross, future president of the American Medical Association and one of the founders of the American Surgical Association, wrote regarding surgeons performing thyroidectomies, "every stroke of his knife will be followed by a torrent of blood and lucky it would be for him if his victim lives long enough to enable him to finish his horrid butchery" [4]. Multiple world renowned surgeons advanced and modified thyroid surgery, but it is Theodor Kocher, with his pioneering work in Berne during the late 1800s and early 1900s, who revolutionized the procedure [1,2]. His emphasis of meticulous technique using delicate instruments through a transverse transcervical approach, focused on careful dissection to reduce morbidity and mortality from bleeding, nerve injury, and hypoparathyroidism. This practice was improved upon and fine-tuned by other eminent surgeons, including William S. Halsted, Charles Mayo, and George Crile in the United States and has remained the standard of care [1,2]. Over the last 20 years, to limit or eliminate an anterior neck scar, a variety of endoscopic approaches were developed.

Endoscopic approaches to parathyroidectomy and thyroid lobectomy were published in 1996 and 1997, respectively [5,6]. These techniques used small anterior cervical incisions and video assistance with a laparoscope [7–12]. These methods evolved permitting remote access, eliminating all anterior neck incisions, as summarized in Table 1.

The transaxillary approach uses 3 axillary ports, allowing access to the ipsilateral neck [13,14]. The transbreast approach uses a trocar at the parasternal border of the breast and bilateral trocars at the superior areolar margin, enabling access to both thyroid lobes [15–17]. A combined axillary and breast approach improves triangulation but results in multiple incisions and significant flap dissection. The unilateral axillobreast approach allows for access to the ipsilateral thyroid lobe, and the axillobilateral breast and bilateral axillobreast approaches allow for visualization and resection of the entire thyroid gland [18–22]. To avoid breast involvement, the retroauricular approach was developed, involving 3 ports behind the ipsilateral ear [23].

Each of these approaches, although avoiding a cervical incision, impose incremental risks compared with conventional surgery. The large flaps and

Table 1
Remote access approaches to the thyroid gland

Transaxillary	Transbreast	Retroauricular
With or without robot assistance	Bilateral supra-areolar incisions with parasternal incision	With or without robot assistance
Three ports in axilla	Bilateral breast incisions with axillary incision	Three ports posterior to the ear
Option of single incision laparoscopic approach	Ipsilateral breast and axillary approach	Incision along the hairline
Access only to ipsilateral lobe	Bilateral axillary, bilateral breast approach	Can facilitate concomitant neck lift
	Access to entire thyroid gland	

extensive dissections are associated with increased bleeding and seroma formation. Specific peripheral nerves, including branches of the brachial plexus (transaxillary approach), the greater auricular nerve, and the spinal accessory nerve (retroauricular approach), are at increased risk. Furthermore, given the extent of dissection, these techniques are not minimally invasive. Ideally, minimally invasive thyroidectomy should follow the principles summarized in Box 1.

DEVELOPMENT OF TRANSORAL THYROIDECTOMY

With the dual goals of creating a minimally invasive approach and improving cosmetic results, transoral access to the thyroid gland developed. NOTES techniques were used, eliminating external incisions and visible scarring. Using the embryologic development and migration of the thyroid gland as a guide, the surgery was developed in a porcine model and in cadavers. Initially, an incision was made in the floor of the mouth and dissection carried down to the thyroid navigating and protecting the submandibular gland, esophagus, hypoglossal muscle, and the hypoglossal, superior laryngeal, and internal laryngeal nerves

Box 1: Principles of minimally invasive surgery

Minimal trauma from access
Close proximity to the operative field
Optimal operative visualization
Surgical resection equivalent to conventional approach
Morbidity profile similar to conventional approach
Equivalent specimen retrieval for histologic analysis
Improved cosmetic outcome

[24–26]. However, this technique caused significant tissue damage and had a high complication rate, most notably hypoglossal nerve injuries [24,27].

The vestibular technique was subsequently developed to improve the risk profile of this NOTES approach [28,29]. The transoral endoscopic thyroidectomy vestibular approach (TOETVA) allows for thyroidectomy using conventional laparoscopic instruments accessing the thyroid through the oral vestibule of the lower lip, traversing the premandibular space. This technique has been proven to be a safe and feasible approach, causing less tissue trauma compared with other remote access methods [29]. Specifically, the hypoglossal nerve is no longer in the operative field.

TOETVA has been refined by Anuwong and colleagues [29–32], who published their 60-patient series in 2016 and subsequently performed more than 500 cases at Police General Hospital, Bangkok, Thailand with minimal complications and excellent results. Having visited and observed Anuwong operating in Bangkok and then having him assist with the development of the first transoral thyroidectomy program in the United States, the authors can attest to his skills and continuous improvement of this technique [33]. Its use has been increasing, and it is now being performed in at least 14 countries: Thailand, Singapore, Indonesia, the Philippines, China, South Korea, Taiwan, Hong Kong, India, Italy, Mexico, Ecuador, Japan, and the United States [34]. In the United States, programs have been established in a few cities, including New Haven, Baltimore, Boston, San Francisco, New York, and Miami.

INDICATIONS AND PATIENT SELECTION

TOETVA can be used for a multitude of thyroid pathologic conditions. Although individual programs may limit cases in the initial phase of implementation, once adopted, these programs generally expand the applications. It can be used for unilateral or bilateral thyroid resection and central lymph node dissection. Indications include benign or indeterminate thyroid nodules, thyroid cysts, toxic adenomas, Graves disease, and many thyroid cancers. Table 2 summarizes the general indications and relative contraindications for TOETVA. Additional patient characteristics that must be considered include

Table 2
Indications and relative contraindications for transoral endoscopic thyroidectomy vestibular approach

Indications	Relative contraindications
Benign thyroid nodule(s)	Nodule size >10 cm
Indeterminate thyroid nodule(s)	Unable to tolerate general anesthesia/nasal intubation
Follicular neoplasm	Caution in patients with:
Hürthle cell neoplasm	Previous neck surgery
Thyroid cancer without lateral neck disease	Previous neck radiation
Well-controlled Graves disease	Compromised oral hygiene

body habitus, chin size, neck extension, previous cervical surgery, and oral hygiene.

SURGICAL TECHNIQUE

Preparation and positioning

Preoperative antibiotics are administered approximately 30 minutes before incision. General anesthesia is induced with nasotracheal intubation to keep the mouth free for surgical instrumentation. The patient is placed in the supine position, using a thyroid pillow behind the shoulders and a head ring under the occiput to obtain optimal neck extension. The skin is prepared from the upper lip to the upper chest and draped, permitting exposure from the mouth to the sternal notch, including the lateral aspects of the neck, as shown in Fig. 1. The wide skin preparation facilitates conversion to a conventional transcervical approach if necessary. The oral vestibule is prepared and rinsed with a chlorhexidine gluconate solution.

Access

A 10-mm transverse incision is made in the midline of the oral vestibule, just above the inferior labial frenulum, as depicted in Fig. 2. Electrocautery and blunt dissection are used to divide the submucosa and mentalis muscle to reach the edge of the mandible. Hydrodissection using a Varess needle and injecting an epinephrine/saline solution (1 mg epinephrine in 500 mL normal saline) initiates the creation of the subplatysmal flap to the level of the sternal notch. A blunt dissector, as exampled in Fig. 3, is passed into this space in a fan-shaped manner to create a working dome. A 10-mm trocar is inserted, and CO_2 insufflation is initiated and maintained at 6 mm Hg. Bilateral 5-mm incisions are made lateral to the canine teeth, perpendicular to and just inside the lower vermillion border to avoid the terminal branches of the mental nerves. Two 5-mm trocars are inserted parallel to the central port, as shown in Fig. 4.

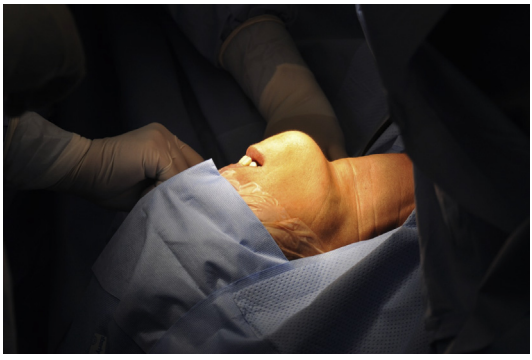

Fig. 1. Patient position after nasotracheal intubation. The head is hyperextended, and the patient is draped with exposure of the mouth and anterior neck.

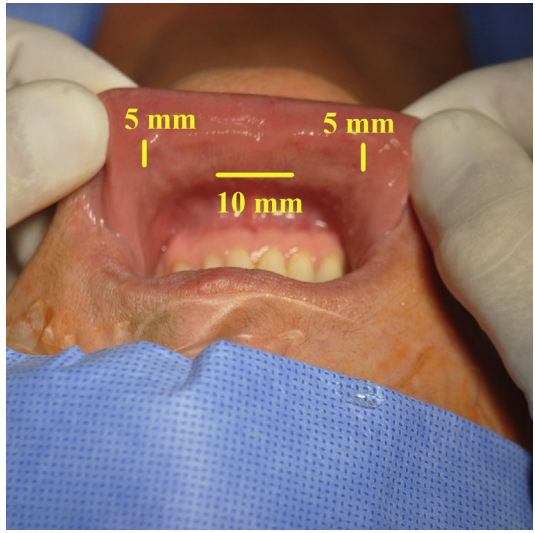

Fig. 2. Incision location in the oral vestibule of the lower lip. The 10-mm transverse incision is placed in the midline just anterior to the inferior labial frenulum. Bilateral 5-mm incisions are made internal to the lower vermillion border, lateral to the canine teeth.

Exposure

A 10-mm 30° laparoscope is placed in the central port. It is helpful to use a continuous airflow system to evacuate gas and smoke, which can compromise operative visualization while insufflating because the working space is relatively small. An external trapdoor suture is placed in the anterior midline of the neck to elevate the skin, subcutaneous tissue, and platysma, expanding the operative space. A combination of monopolar electrocautery and an ultrasonic or thermal energy device is used to complete dissection of the subplatysmal space inferiorly to the sternal notch, laterally to the edges of sternocleidomastoid muscles, and superiorly to the border of the thyroid cartilage. The strap

Fig. 3. Anuwong-Udelsman dual-head blunt transoral dissector. This instrument was custom made to fit through a 10-mm port for creation of the operative dome. This dilator was manufactured by DM Surgical LLC, Cheshire, Connecticut, USA.

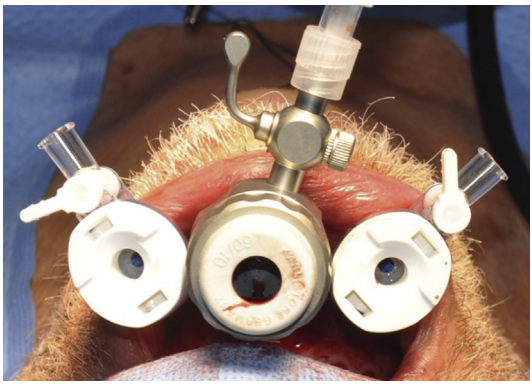

Fig. 4. Port placement in the lower lip. The central 10-mm port is used for insufflation with continuous air exchange and for use of a 10-mm 30° laparoscope. The two 5-mm ports are used for instrumentation.

muscles are mobilized by dividing the median raphe and dissecting them off the thyroid to expose the ipsilateral lobe. A second trap door suture can be used laterally through the skin to retract the strap muscles. If necessary, the sternothyroid muscle can be divided partially or completely at its superior insertion to facilitate visualization of the superior pole of the thyroid.

Dissecting the thyroid

Thyroid mobilization is initiated at the pyramidal lobe, extended along the trachea, transecting the gland through the isthmus along the border of the contralateral lobe. The avascular plane between the thyroid and cricothyroid muscle is opened, exposing the superior pole vessels. These vessels are ligated directly on the thyroid capsule to protect the external branch of the superior laryngeal nerve and the superior parathyroid gland. The gland is rotated medially to expose the tracheoesophageal groove and the recurrent laryngeal nerve (RLN). The RLN is traced proximally as the thyroid is mobilized and retracted medially, as shown in Fig. 5. Inferiorly, dissection of the thyroid gland stays on the capsule to preserve the lower parathyroid gland. The ligament of Berry is divided, protecting the RLN and trachea as the remaining pretracheal fascia is transected. For a total thyroidectomy, the procedure is replicated on the contralateral side. When indicated, a central neck lymph node dissection can easily be performed with this approach. Fig. 6 shows an extracted thyroid lobe with the ipsilateral central neck lymph node dissection.

Specimen retrieval and closure

A specimen retrieval pouch is placed through the center port. The specimen is placed into the pouch and delivered through the central incision after removal of the trocar. If necessary with large specimens, the thyroid capsule may be cut within the retrieval pouch to facilitate specimen compression and extraction. To preserve the specimen for histopathologic analysis, thyroid nodules are

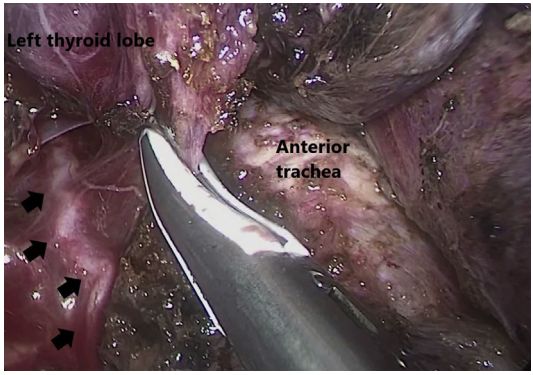

Fig. 5. Intraoperative dissection of the thyroid gland. The left thyroid lobe has been mobilized and rotated medially, and the thermal energy device is transecting the ligament of Berry. The left RLN is demarcated with black arrows.

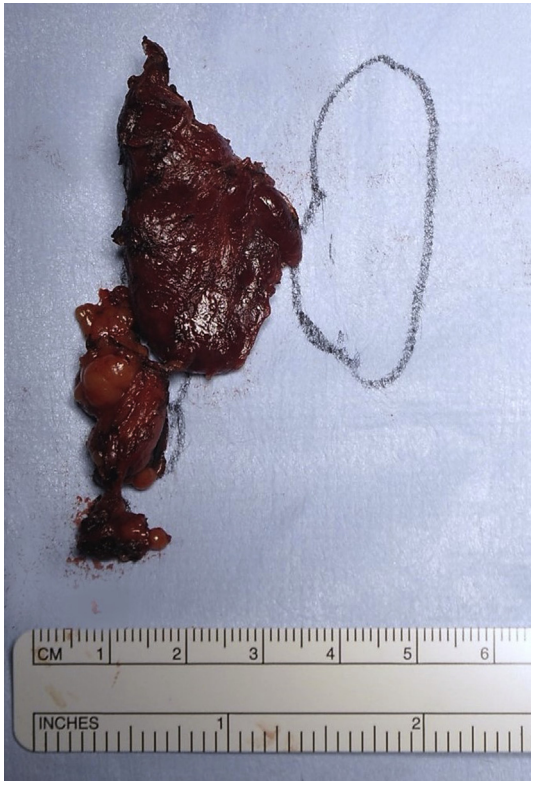

Fig. 6. Right thyroid lobe with the associated central lymph nodes after extraction on a patient with papillary thyroid cancer.

not compromised. After ensuring hemostasis, the strap muscles are reapproximated with a running suture. Residual CO_2 is evacuated, and the trocars are removed. The mentalis muscle is reapproximated, and the lip mucosa is closed with absorbable sutures.

Postoperative management

A facelift compression wrap is placed over an anterior cervical gauze pressure dressing. The patient is admitted to the hospital, and prophylactic antibiotics are continued for 24 hours. Patients are restricted to a liquid diet for the night of surgery, and an oral mouthwash is used 4 times a day. These patients are closely monitored for signs of bleeding, vocal cord paresis, or difficulty breathing. If they have undergone a total thyroidectomy, serum calcium levels are measured. On postoperative day 1, patients are offered a solid diet and generally discharged home.

SURGICAL RESULTS

Surgical procedures include thyroid lobectomy, isthmusectomy, subtotal or near-total thyroidectomy, and total thyroidectomy with or without a central neck dissection. The results following these procedures are favorable, and complication rates are low. The largest published experience shows complication rates at or less than 5% for major complications, and reported infections are rare. Overall, the morbidity profile is comparable to that of a conventional approach. A review of the published worldwide data for TOETVA is summarized in Table 3 [28–33,35–52].

SURGICAL COMPLICATIONS

In addition to the complications associated with conventional thyroidectomy, including bleeding, RLN injury, injury to the external branch of the superior laryngeal nerve, and hypoparathyroidism, TOETVA carries added risk. Although infection after conventional thyroidectomy is rare, the infection risk with TOETVA is theoretically increased. Using the oral cavity for access changes the case categorization from a clean to a clean-contaminated field. Consequently, perioperative antibiotic prophylaxis is standard for TOETVA, while unnecessary for a conventional approach [29–32]. Although reported infection rates vary, the largest single-institution case series showed a 0% infection rate [32]. Careful oral preparation, prophylactic antibiotics, and meticulous technique minimizing tissue trauma and eliminating dead space contribute to this success [26,29,30,32]. Seroma formation and subcutaneous emphysema are more common, occurring 3.5% to 5% of the time, but rarely require intervention. Subcutaneous emphysema is not in itself a complication and should be expected in most patients because of insufflation. It is almost always self-limiting and resolves spontaneously within 3 to 5 days.

Mental nerve palsy or injury causing sensory disorders of the lower lip and chin is a complication unique to this approach because the lateral ports traverse close to terminal branches of the mental nerve. The transposition of the lateral

Table 3
Worldwide transoral endoscopic thyroidectomy vestibular approach experience

Author, y	Cases	Indications	Procedures	Complications
Nakajo et al [35], 2013	8	3 PTC 4 Follicular adenoma 1 Goiter	5 Lobectomy 3 Subtotal, CND	1 RLN injury
Wang et al [28], 2014	12	12 Goiter	8 Lobectomy 4 TT	None
Yang et al [36], 2015	41	34 Goiter 3 Hyperthyroidism 4 PTC	19 Lobectomy 18 Subtotal/near-TT 4 TT, CND	2 Jaw ecchymosis 1 Skin puncture 1 Skin burn 1 Transient RLN palsy
Pai et al [37], 2015	1	1 Indeterminate	1 Lobectomy	None
Anuwong [29], 2016	60	42 Single nodule 2 Graves 2 PTC	42 Lobectomy 2 TT or near-TT 2 TT, CND	2 Transient hoarseness 1 Delayed hematoma 1 Transient hypoparathyroidism
Udelsman et al [33], 2016	5	1 Toxic adenoma 2 Goiter 1 Indeterminate 1 PTC	3 Lobectomy 1 TT 1 TT, CND	None
Inabnet et al [38], 2017	1	1 Toxic adenoma	1 Lobectomy	
Park et al [39], 2016	1	1 Indeterminate	1 Lobectomy	None
Jitpratoom et al [40], 2016	45	45 Graves	45 TT or near-TT	1 Conversion to open 10 Transient hypoparathyroidism
Yang et al [41], 2016	6	6 Solitary nodule	5 Partial thyroidectomy 1 Unilateral subtotal	1 Wound infection
Zeng et al [42], 2016	4	4 Goiter	4 TT	None
Dionigi et al [43], 2017	15	7 Single nodule 5 Goiter 2 Toxic adenoma 1 PTC	10 Lobectomy 5 TT	1 Transient hypocalcemia
Park & Sun [44], 2017	18[a]	6 Single nodule 11 PTC 1 Follicular carcinoma	15 Lobectomy 1 Completion 2 TT	1 Transient hypocalcemia 2 Seroma

(*continued on next page*)

Table 3
continued

Author, y	Cases	Indications	Procedures	Complications
Chai et al [45], 2017	10	10 PTC	7 Lobectomy 3 Isthmusectomy	2 Transient RLN palsy
Russell et al [46], 2017	6	6 Single nodule	6 Lobectomy	1 Temporary RLN palsy
Anuwong et al [32], 2018	200	110 Single nodule/cyst 66 Goiter 13 Graves 11 PTC	111 Lobectomy 89 TT or near-TT	8 Transient RLN palsy 35 Transient hypoparathyroidism 3 Transient mental nerve palsy 10 Seroma formation 1 Postoperative hematoma
Bakkar et al [47], 2018	5	5 Single nodule	5 Lobectomy	1 Conversion to open 1 Flap perforation
Anuwong et al [30], 2018	425	245 Single nodule/cyst 118 Goiter 33 Graves 26 PTC	245 Lobectomy 177 TT or near-TT	3 Conversion to open 25 Transient RLN palsy 46 Transient hypoparathyroidism 3 Transient mental nerve palsy 20 Seroma formation 1 Postoperative hematoma
Razavi et al [48], 2018	2[a]	1 Single nodule 1 Hürthle cell carcinoma	1 Lobectomy 1 Completion thyroidectomy	None
Yi et al [49], 2018	20	19 PTC 1 Follicular neoplasm	12 Lobectomy 1 Isthmusectomy 7 TT	1 Transient RLN palsy 1 Seroma 3 Transient hypocalcemia
Zhang et al [50], 2018	1	1 Indeterminate	1 TT	1 Transient hypocalcemia, extensive subcutaneous emphysema
Sivakumar and Amizhthu [51], 2018	11	11 Goiter	11 TT	None
Fu et al [52], 2018	81	65 Unilateral nodule 5 Goiter 6 Isthmus nodule 5 PTC	65 Lobectomy 6 Isthmusectomy 5 Subtotal 5 TT	2 Converted to open 2 Transient perioral numbness

Abbreviations: CND, central neck dissection; PTC, papillary thyroid cancer; TT, total thyroidectomy.
[a]Greater than 1 case in same patient.
Data from Refs [28–33,35–52].

working ports from anterior to the canines to the inferior vermillion border lateral to the canines appears to have reduced this risk; however, transient paresthesia from terminal branch mental nerve palsy is seen in 1% to 2% of these patients.

IMPLEMENTATION

Developing a successful transoral thyroidectomy program is a complex process that requires a multidisciplinary effort. After obtaining approval from institutional review committees, there must be an organized approach with anesthesia, pathology, operating room staff, surgical nursing, the postoperative surgical team, and hospital leadership. Specifically, a dedicated operating room team, including anesthesia, nursing, and scrub staff, greatly improves adoption, and more importantly, patient safety. Pathology needs to be involved, in case there is disruption or distortion of the specimen from extraction through the oral vestibule. Hospital credentialing will vary among institutions but must be obtained preemptively.

To succeed in implementation of the TOETVA program, a surgeon's preparation is extensive. Although the concept of dissecting the thyroid remains the same, this technique is more difficult to learn and perform. It is advantageous to practice using laparoscopic trainers and to visit centers already performing the procedure to observe. Ideally, a mentor who is actively performing the procedure will assist in training and implementation.

PARATHYROID APPLICATION

The transoral endoscopic vestibular approach has also been used for parathyroidectomy in patients with a well-localized adenoma and primary hyperparathyroidism. Although feasible, it is not an ideal alternative to the traditional approach for multiple reasons. Primarily, it is not clear preoperatively when a planned minimally invasive resection of a presumed single adenoma will require bilateral exploration for occult multigland disease and a subtotal parathyroid resection to achieve cure. Although bilateral exploration via the transoral approach is possible, it is more complicated than with the conventional approach. In addition, multiple ectopic parathyroid gland locations are best approached by a traditional transcervical incision, such as accessing a parathyroid gland within the carotid sheath or low within the mediastinal thymus.

DISCUSSION

The development of alternative and remote approaches to the thyroid is driven by cosmetic concerns. There are significant social differences and aesthetic concerns around the world that push this to the forefront. In Asia, an anterior neck scar is often considered disfiguring. In every population, however, there are subgroups whereby aesthetics and cosmetic surgical results are prioritized. For these patients, TOETVA offers an excellent alternative to the conventional cervical incision. Compared with other remote access approaches, TOETVA is

particularly attractive. It has a similar morbidity profile to conventional thyroid surgery with low complication rates and is truly a minimally invasive approach. Although implemented in many institutions, the other remote access techniques have frequently been abandoned.

In the western world, TOETVA is not likely a method that will become the standard of care in all centers. Rather, it is a specialized approach, likely to be offered in select institutions for appropriate patients, performed by surgeons committed to learning and implementing this technique. Although current results are favorable, those with the most experience continue to adjust and fine tune the procedure to improve outcomes. Although it is applicable for multiple indications, the case numbers required to become and remain proficient necessitate a large referral base because a fraction of those patients will be willing and appropriate to proceed. During the initial implementation, operative times are longer. With increased experience, however, operative times approach conventional thyroid surgery.

SUMMARY

Kocher's transverse cervical incision has been the standard surgical approach for thyroidectomy for more than 100 years. Now, for those patients with aesthetic concerns who wish to avoid an anterior neck scar, remote access surgical techniques have been developed. TOETVA offers a minimally invasive NOTES approach without visible scarring and a low complication rate. Although it is increasingly performed in Asian countries, the western experience is limited. TOETVA shows great potential to become an accepted alternative approach for select surgeons in institutions committed to establishing programs.

References

[1] Welbourn RB, Friesen SR, Johnston IDA, et al. The history of endocrine surgery. New York: Praeger Publishers; 1990.
[2] Giddings AEB. The history of thyroidectomy. J R Soc Med 1998;91(33_Supplemental):3–6.
[3] Sarkar S, Banerjee S, Sarkar R, et al. A review on the history of 'thyroid surgery'. Indian J Surg 2016;78(1):32–6.
[4] Gross SD. 4th edition. A system of surgery: pathologic, diagnostic, therapeutic, and operative, vol. ii. Philadelphia: Henry C Lea; 1866.
[5] Gagner M. Endoscopic subtotal parathyroidectomy in patients with primary hyperparathyroidism. Br J Surg 1996;83(6):875.
[6] Huscher CS, Chiodini S, Napolitano C, et al. Endoscopic right thyroid lobectomy. Surg Endosc 1997;11(8):877.
[7] Miccoli P, Berti P, Raffaelli M, et al. Comparison between minimally invasive video-assisted thyroidectomy and conventional thyroidectomy: a prospective randomized study. Surgery 2001;130(6):1039–43.
[8] El-Labban GM. Minimally invasive video-assisted thyroidectomy versus conventional thyroidectomy: a single-blinded, randomized controlled clinical trial. J Minim Access Surg 2009;5(4):97–102.
[9] Miccoli P, Bellantone R, Mourad M, et al. Minimally invasive video-assisted thyroidectomy: multiinstitutional experience. World J Surg 2002;26(8):972–5.

[10] Terris DJ, Gourin CG, Chin E. Minimally invasive thyroidectomy: basic and advanced techniques. Laryngoscope 2006;116(3):350–6.
[11] Bellantone R, Lombardi CP, Raffaelli M, et al. Minimally invasive, totally gasless video-assisted thyroid lobectomy. Am J Surg 1999;177(4):342–3.
[12] Shimizu K, Akira S, Jasmi AY, et al. Video-assisted neck surgery: endoscopic resection of thyroid tumors with a very minimal neck wound. J Am Coll Surg 1999;188(6):697–703.
[13] Ikeda Y, Takami H, Niimi M, et al. Endoscopic thyroidectomy and parathyroidectomy by the axillary approach. A preliminary report. Surg Endosc 2002;16(1):92–5.
[14] Ikeda Y, Takami H, Sasaki Y, et al. Endoscopic neck surgery by the axillary approach. J Am Coll Surg 2000;191(3):336–40.
[15] Ohgami M, Ishii S, Arisawa Y, et al. Scarless endoscopic thyroidectomy: breast approach for better cosmesis. Surg Laparosc Endosc Percutan Tech 2000;10(1):1–4.
[16] Sasaki A, Nakajima J, Ikeda K, et al. Endoscopic thyroidectomy by the breast approach: a single institution's 9-year experience. World J Surg 2008;32(3):381–5.
[17] Kim YS, Joo KH, Park SC, et al. Endoscopic thyroid surgery via a breast approach: a single institution's experiences. BMC Surg 2014;14:49.
[18] Shimazu K, Shiba E, Tamaki Y, et al. Endoscopic thyroid surgery through the axillo-bilateral-breast approach. Surg Laparosc Endosc Percutan Tech 2003;13(3):196–201.
[19] Choe JH, Kim SW, Chung KW, et al. Endoscopic thyroidectomy using a new bilateral axillo-breast approach. World J Surg 2007;31(3):601–6.
[20] Choi JY, Lee KE, Chung K-W, et al. Endoscopic thyroidectomy via bilateral axillo-breast approach (BABA): review of 512 cases in a single institute. Surg Endosc 2012;26(4):948–55.
[21] Koh YW, Kim JW, Lee SW, et al. Endoscopic thyroidectomy via a unilateral axillo-breast approach without gas insufflation for unilateral benign thyroid lesions. Surg Endosc 2009;23(9):2053–60.
[22] Bodade RM, Dhoran AP, Dhurve AS, et al. Endoscopic thyroidectomy-axilla breast approach: the experience of 26 cases. International Surgery Journal 2018;5(2):593–7.
[23] Lee KE, Kim HY, Park WS, et al. Postauricular and axillary approach endoscopic neck surgery: a new technique. World J Surg 2009;33(4):767–72.
[24] Karakas E, Steinfeldt T, Gockel A, et al. Transoral thyroid and parathyroid surgery. Surg Endosc 2010;24(6):1261–7.
[25] Karakas E, Steinfeldt T, Gockel A, et al. Transoral thyroid and parathyroid surgery–development of a new transoral technique. Surgery 2011;150(1):108–15.
[26] Karakas E, Anuwong A, Ketwong K, et al. [Transoral thyroid and parathyroid surgery: implementation and evaluation of the transoral endoscopic technique via the vestibular approach (TOETVA)]. Chirurg 2018;89(7):537–44.
[27] Wilhelm T, Metzig A. Endoscopic minimally invasive thyroidectomy (eMIT): a prospective proof-of-concept study in humans. World J Surg 2011;35(3):543–51.
[28] Wang C, Zhai H, Liu W, et al. Thyroidectomy: a novel endoscopic oral vestibular approach. Surgery 2014;155(1):33–8.
[29] Anuwong A. Transoral endoscopic thyroidectomy vestibular approach: a series of the first 60 human cases. World J Surg 2016;40(3):491–7.
[30] Anuwong A, Ketwong K, Jitpratoom P, et al. Safety and outcomes of the transoral endoscopic thyroidectomy vestibular approach. JAMA Surg 2018;153(1):21–7.
[31] Anuwong A, Kim HY, Dionigi G. Transoral endoscopic thyroidectomy using vestibular approach: updates and evidences. Gland Surg 2017;6(3):277–84.
[32] Anuwong A, Sasanakietkul T, Jitpratoom P, et al. Transoral endoscopic thyroidectomy vestibular approach (TOETVA): indications, techniques and results. Surg Endosc 2018;32(1):456–65.
[33] Udelsman R, Anuwong A, Oprea AD, et al. Trans-oral vestibular endocrine surgery: a new technique in the United States. Ann Surg 2016;264(6):e13–6.

[34] Dionigi G, Chai YJ, Tufano RP, et al. Transoral endoscopic thyroidectomy via a vestibular approach: why and how? Endocrine 2018;59(2):275–9.
[35] Nakajo A, Arima H, Hirata M, et al. Trans-oral video-assisted neck surgery (TOVANS). A new transoral technique of endoscopic thyroidectomy with gasless premandible approach. Surg Endosc 2013;27(4):1105–10.
[36] Yang J, Wang C, Li J, et al. Complete endoscopic thyroidectomy via oral vestibular approach versus areola approach for treatment of thyroid diseases. J Laparoendosc Adv Surg Tech A 2015;25(6):470–6.
[37] Pai VM, Muthukumar P, Prathap A, et al. Transoral endoscopic thyroidectomy: a case report. Int J Surg Case Rep 2015;12:99–101.
[38] Inabnet WB 3rd, Suh H, Fernandez-Ranvier G. Transoral endoscopic thyroidectomy vestibular approach with intraoperative nerve monitoring. Surg Endosc 2017;31(7):3030.
[39] Park JO, Kim MR, Kim DH, et al. Transoral endoscopic thyroidectomy via the trivestibular route. Ann Surg Treat Res 2016;91(5):269–72.
[40] Jitpratoom P, Ketwong K, Sasanakietkul T, et al. Transoral endoscopic thyroidectomy vestibular approach (TOETVA) for Graves' disease: a comparison of surgical results with open thyroidectomy. Gland Surg 2016;5(6):546–52.
[41] Yang K, Ding B, Lin C, et al. The novel transvestibule approach for endoscopic thyroidectomy: a case series. Surg Laparosc Endosc Percutan Tech 2016;26(1):e25–8.
[42] Zeng YK, Li ZY, Xuan WL, et al. Trans-oral glasses-free three-dimensional endoscopic thyroidectomy-preliminary single center experiences. Gland Surg 2016;5(6):628–32.
[43] Dionigi G, Bacuzzi A, Lavazza M, et al. Transoral endoscopic thyroidectomy: preliminary experience in Italy. Updates Surg 2017;69(2):225–34.
[44] Park JO, Sun DI. Transoral endoscopic thyroidectomy: our initial experience using a new endoscopic technique. Surg Endosc 2017;31(12):5436–43.
[45] Chai YJ, Chung JK, Anuwong A, et al. Transoral endoscopic thyroidectomy for papillary thyroid microcarcinoma: initial experience of a single surgeon. Ann Surg Treat Res 2017;93(2):70–5.
[46] Russell JO, Clark J, Noureldine SI, et al. Transoral thyroidectomy and parathyroidectomy—a North American series of robotic and endoscopic transoral approaches to the central neck. Oral Oncol 2017;71:75–80.
[47] Bakkar S, Al Hyari M, Naghawi M, et al. Transoral thyroidectomy: a viable surgical option with unprecedented complications-a case series. J Endocrinol Invest 2018;41(7):809–13.
[48] Razavi CR, Tufano RP, Russell JO. Completion thyroidectomy via the transoral endoscopic vestibular approach. Gland Surg 2018;7(Suppl 1):S77–9.
[49] Yi JW, Yoon SG, Kim HS, et al. Transoral endoscopic surgery for papillary thyroid carcinoma: initial experiences of a single surgeon in South Korea. Ann Surg Treat Res 2018;95(2):73–9.
[50] Zhang D, Wu CW, Inversini D, et al. Lessons learned from a faulty transoral endoscopic thyroidectomy vestibular approach. Surg Laparosc Endosc Percutan Tech 2018;28(5):e94–9.
[51] Sivakumar T, Amizhthu RA. Transoral endoscopic total thyroidectomy vestibular approach: a case series and literature review. J Minim Access Surg 2018;14(2):118–23.
[52] Fu J, Luo Y, Chen Q, et al. Transoral endoscopic thyroidectomy: review of 81 cases in a single institute. J Laparoendosc Adv Surg Tech A 2018;28(3):286–91.