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Indications, benefits and risks of transoral thyroidectomy

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The advancement of minimally invasive surgery in the field of endocrine surgery over the last 2 decades has fostered the attempt of natural orifice transluminal endoscopic surgery (NOTES) for thyroidectomy and parathyroidectomy via oral incisions. This technically demanding surgery is currently being evaluated in a number of specialised centres. The procedure has gained popularity worldwide and is performed in more than 50 centres. By retrieving information from published or presented articles and

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indications
results
morbidity

direct personal communications, this study reports several issues to enable and optimise correct patient and surgeon candidacy, present the advantages and prevent novel complications under the standards of open thyroid surgery. Not all patients are eligible for the transoral approach. Transoral endoscopic and robotic procedures were described and critically analysed in this study.

Introduction

Conventional open thyroidectomy via a neck incision remains the standard of care performed worldwide for various thyroid diseases [1]. However, the increased incidence of thyroid pathology with a growing social emphasis on the physical appearances among the younger, female-predominant patient population motivated many surgeons to explore aesthetically favourable alternative approaches in thyroid surgery [2,3]. Thus far, many previous alternative thyroidectomy techniques represented surgical compromise between exposure and aesthetics – it was a choice between a small but still visible scar and a remote, hidden scar requiring extensive tissue dissection [4]. When the endoscopic approach was introduced in thyroid surgery, it was initially argued that it might not be beneficial for the patient, except in terms of offering better cosmesis [1–5]. Since then, several benefits of endoscopic thyroid surgery, including decreased postoperative swallowing problems, better voice quality, less pain, faster recovery and decreased incidence of wound-related complications, have been recognised while maintaining standard endocrine results such as complication rate and completeness of the procedure [6–10]. In spite of initial scepticism, endoscopic and robotic thyroid surgeries have recently become alternative approaches among selected patients and have been accepted in some oncological procedures [11,12]. With the continued evolution of endoscopy and robotics in thyroid surgery and the increasing awareness on the impact of the degree of surgical invasiveness on patient outcomes, it was perhaps inevitable that natural orifice transluminal endoscopic surgery (NOTES) would eventually be proposed and applied in endocrine surgery (Fig. 1 and Table 1) [13–27]. This theoretical point has a potential clinical application considering the proximity of the thyroid gland to

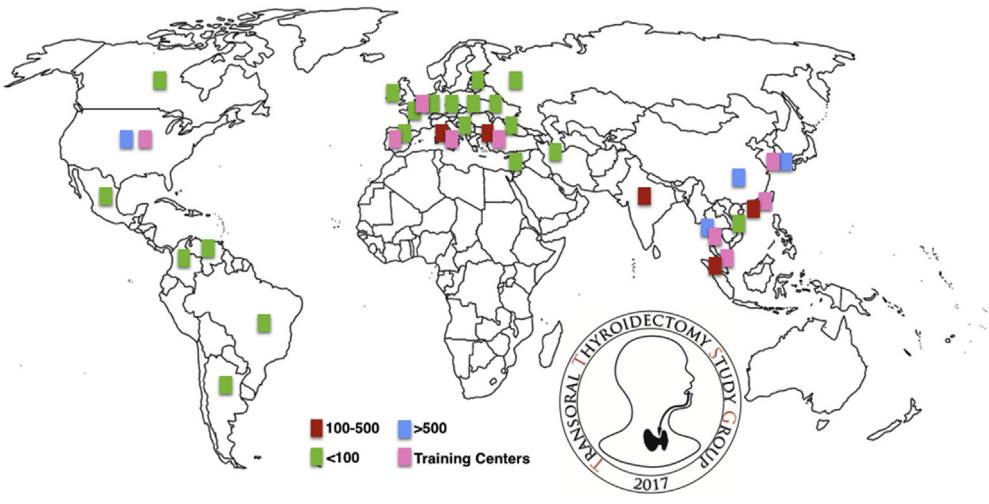

Fig. 1. Transoral thyroidectomy is a reproducible, multi-institutional procedure. 79 Centers from 28 Countries applied the technique (data set, March 2019). There are Training Centers in Germany, Hong Kong, Italy, Korea, Singapore, Spain, Thailand, Turkey, USA.

Table 1
Classification of different transoral thyroidectomy approaches. Submental incision has been described in plastic surgery for neck lift procedures such as the corset platysmaplasty. Submental route for tumor extraction should theoretically allow larger nodules to be extracted intact due to a shorter tissue flap and avoidance of the inflexible chin. The trans-tracheal approach is experimental only.

- Sublingual approach
- Combined sublingual and oral vestibular approach
- Oral vestibular approach
- Combined transoral and submental
- Trans-tracheal approach

the oral cavity, natural origin from the primitive pharyngeal floor and median tongue bud and median approach resulting in bilateral exposure (Figs. 2 and 3 and Table 2). The established benefits of endoscopic procedures over the conventional surgery in terms of cosmetic results, increasing technological developments, and increasing the skill set of some endocrine surgeons in performing surgeries using video endoscope imaging and pneumo-neck raised the possibility of replicating NOTES for the excision of the thyroid and parathyroid glands (Fig. 4 and Table 3) [13–27]. The evolution of the present technique began with a sublingual transoral approach, which involves piercing through the floor of the mouth resulting in severe tissue damages and high complications. Hence, the oral vestibular approach was used to create vestibular incisions anterior to the mandible between the mentalis muscles.

Indications

Miccoli's principles of selection and exclusion criteria for minimally invasive video-assisted thyroidectomy are also currently reproducible for transoral thyroidectomy (TOT) [7–9]. De facto, the TOT selection criteria were derived from preoperative clinical and ultrasound assessments and bio-humoral and cytological tests. The patients must meet the following inclusion criteria: (a) an ultrasonographically (US) estimated thyroid gland diameter $\leq$10 cm, (b) US estimated thyroid volume $\leq$45 mL, (c) US estimated main nodule size $\leq$50 mm, (d) presence of a benign tumour such as a thyroid cyst or a uni- or multinodular goitre, (e) follicular neoplasm or (f) papillary microcarcinoma of the thyroid without evidence of metastasis [28,29]. Patients were excluded if they (a) are unfit for surgery; (b) cannot tolerate general anaesthesia; (c) underwent previous radiation therapy in the head, neck and/or

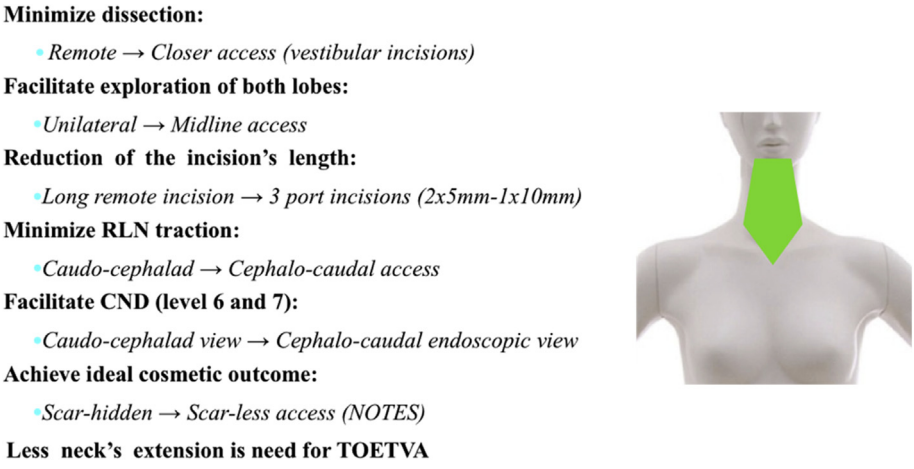

Fig. 2. Concept and possible directions for the development of transoral approach. The transition from unilateral remote axillary, areola and retroauricular approaches towards the median nearer oral approach.

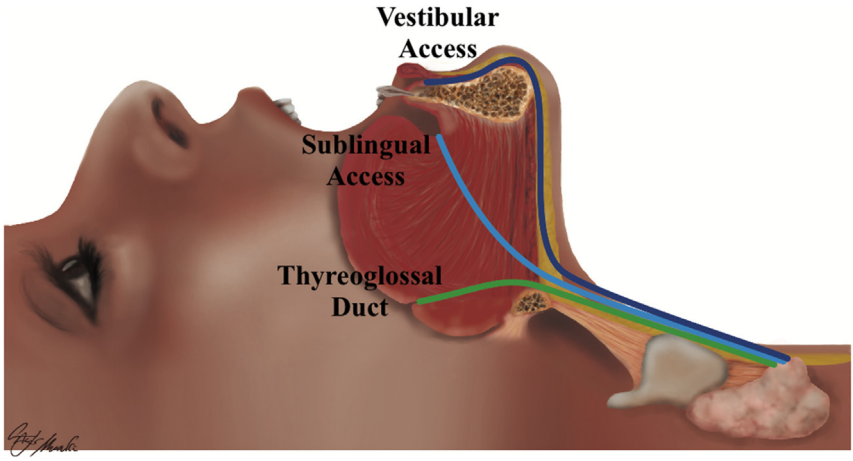

Fig. 3. Sublingual versus vestibular access. Sublingual access presents advantages: (a) closer to thyroiglossal duct, (b) slight less longer approach to gland, (c) no mental nerve injury. Disadvantages for the sublingual access are: (a) severe tissue damage, (b) complication rates, (c) conversion rates, (d) limitation of instrument movement, (e) no instrument availability.

Table 2
The sublingual route, including combination, has experienced decreasing popularity due to the difficulty of the technique and its high complication and conversion rate. Although there are some papers still investigating this technique, it is no longer active in clinical practice.

Advantages	Disadvantages
Sublingual access	
→ Closer to thyroiglossal duct	→ Severe tissue damage
→ Slight less longer approach to gland	→ High complication rates
→ No mental nerve injury	→ Conversion rates
	→ Limitation of movement
	→ No instrument availability
	→ Small number patients

upper mediastinum; (d) had a previous neck surgery; (e) have recurrent goitre; (f) have a thyroid volume >45 mL; (g) have a dominant nodule size >50 mm; or (h) show evidence of lymph node or distant metastases, (i) tracheal/oesophageal invasion (l) recurrent laryngeal nerve (RLN) palsy (m) biochemical sign of hyperthyroidism or (n) oral abscess [28,29]. Patients with poorly differentiated or undifferentiated cancer, posterior extrathyroidal extension and/or N1b differentiated thyroid cancer, large goitre and Graves' disease are not preferred candidates for the transoral approach (Table 4) [28,29]. Most TOT performed were diagnostic hemithyroidectomies for nodules with suspected cytology (Bethesda 3 or 4) [13–29].

Procedure

To develop TOT in a responsible and safe manner, a working group of leading transoral surgeons met in 2016 [28,29]. The primary goal of the meeting was to produce documents that would serve as a guide for responsible development of TOT [28,29]. In the subsequently published white papers, the authors discussed in detail the potential challenges with regard to the safe use of the transoral endoscopic thyroidectomy vestibular approach (TOETVA) in clinical practice and outlined the guidelines for investigators working on TOETVA, and standardised the technique and criteria for expanding participation [28,29].

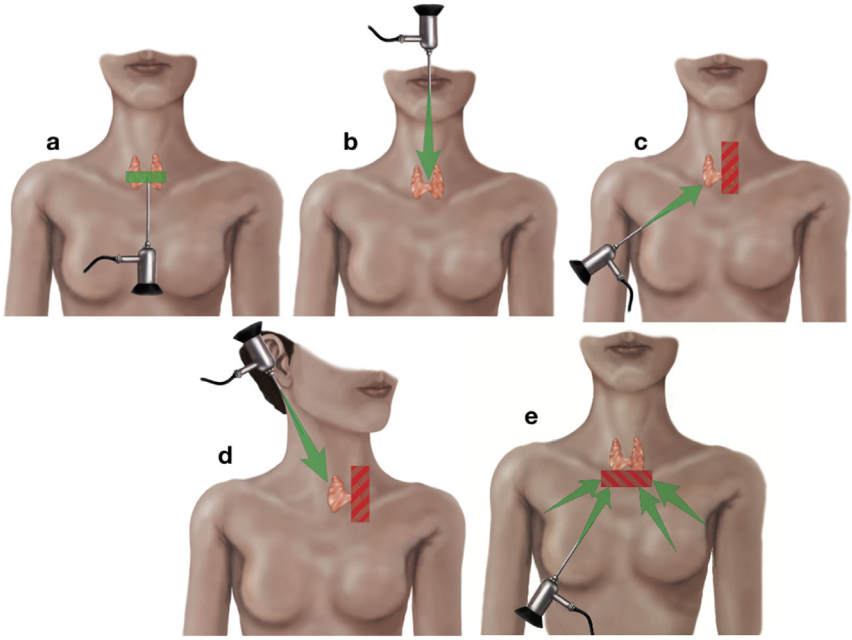

Fig. 4. (a,b,c,d,e). Comparison of endoscopic thyroid approaches. No level I evidence exists comparing these approaches to other remote access approaches or to the traditional trans-cervical Kocher approach to the central neck. (a) Minimally invasive video-assisted thyroidectomy (MIVAT) and (b) transoral endoscopic thyroidectomy vestibular approach (TOETVA) allow for direct, midline, bilateral access to the thyroid gland and neck structures. (c) Axillary, (d) retroauricular and (e) breast approaches need more flap dissection (green). The breast approach provides limited access to the distal central neck compartment, i.e. level 7 (e). The axillary (c) and retroauricular (d) approaches are unilateral approaches allowing limited evaluation of the contralateral neck structures.

Preoperative care

Surgeries are performed according to the thyroid association management guidelines (Table 5). TOETVA is performed under general anaesthesia with naso- or orotracheal intubation [29]. The patients are in a supine position with slight neck extension created by a pillow placed under the shoulders and in a 15° Trendelenburg bed position. The bed is lowered to the height of the first operator, as in a laparoscopic procedure. The operative room setting includes the surgeon who is standing near the patient's head, first assistant surgeon on the left side, nurse on the right side and high definition and intraoperative neural monitoring (IONM) monitor at the patient's foot. Amoxicillin/clavulanic acid is administered as a preoperative prophylactic antibiotic [29]. The patients underwent dental care about 1 month before surgery [29]. Preoperatively, they were asked to gargle with a chlorhexidine mouthwash. The eyes and nose are draped with gauzes for protection.

A sponge is applied on the eyes, nose, and zygomatic bone to protect from accidental compression injuries by an instrument. Once the operative field is properly prepared and draped, oral cavity disinfection is performed using chlorhexidine and povidone-iodine solutions. Skin markings of important anatomical references—midline of the neck, anterior border of the sternocleidomastoid muscle and the clavicles—were made as a guide for flap dissection.

Equipment

The surgical instruments include: a standard neck tray, Veress needle for hydrodissection, straight vascular space creating tunneler probes, Kelly clamp, 1 10-mm trocar, 2 5-mm trocars, 30° 10-mm or 5-

Table 3
Reported studies on transoral thyroidectomy. First report on vestibular incision was by J.D. Richmon (Head Neck, 2011). Initial description on the 3 vestibular incisions was by J.O. Park (Eur Arch Otorhinolaryngol, 2014).

Author	Year	Journal	Subject	Methods
K. Witzel	2008	Surg Endosc	2 cadavers, 10 pigs	Transoral access for endoscopic thyroid resection
T. Wilhelm	2010	Eur Arch Otorhinolaryngol	5 cadavers	Anatomical Study
T. Wilhelm	2011	Surg Endosc	5 pigs	Transoral Endoscopic Thymectomy
T. Wilhelm	2011	World J Surg	8 humans	eMIT: Transoral Thyroidectomy
E. Karakas	2010	Surg Endosc	10 cadavers, 10 pigs	Transoral thyroid and parathyroid surgery (lateral approach for hemithyroidectomy)
E. Karakas	2011	Surgery	2 patients	Transoral thyroid and parathyroid surgery (lateral approach for hemithyroidectomy)
J.D. Richmon	2011	Head & Neck	2 cadavers	Transoral Robotic-Assisted Thyroidectomy
A. Nakajo	2013	Surg Endosc	8 patients	TOVANS (Transoral video-assisted thyroidectomy)
J.O. Park	2014	Eur Arch Otorhinolaryngol	6 cadavers	Transoral Endoscopic Thyroidectomy (Tri-vestibular approach)

Table 4
Patient candidacy: how to choose the TOETVA patient for the beginner. The ideal first case should be a female patient, right lobectomy.

	Comment
Uncomplicated thyroid nodule	• Nodule size: nodule not to small and not too big. A 3 cm nodule is appropriated. It is easy to see endoscopically, it isn't difficult to dissect, it isn't too hard to handle when you look for the RLN, it isn't too complicated to put the nodule into the endobag and removed from the vestibule. • Nodule location: not too low (near the suprasternal notch). Not too high (upper pole dissection). It should be not too deep (posterior lobe), not adhere carotid sheath, hide underneath SCM or difficult to palpate
No obesity or not too short neck	Association between obesity and TOETVA outcomes has not been investigated
ASA 1	Before starting your first trans oral case interact and discuss with your anesthesiologist
No contraindication for nasotracheal intubation	There is an unknown prevalence of EMG tube displacement in transoral thyroidectomy. Surgeon and anesthesiologist ensue standardized tube placement algorithm, with great care to initial EMG tube position. Tube well secured with tape, and pen mark reference placed on tube at the corner of the mouth. Tube verification with repeat laryngoscopy should be routinely performed, after neck extension, before surgery
Preoperative laryngeal examination	Pre-operative RLN palsy is a contraindications for TOETVA
Right lobectomy, female	Male patient is more challenging. The passage from the chin to neck region step has more robust tissue. The laryngeal prominence/thyroid cartilage is larger in adult men, interferes with endoscopic vision and with instrumentation
Right hand surgeon should start operate with right thyroid nodule	Left lobectomy is more challenging for the right hand surgeon: instruments interbreed and (Male patient) for the laryngeal prominence

mm scope, ball tip stimulator probe for IONM, conventional endoscopic instruments such as the Maryland dissector, tissue grasper, needle holder, vascular clips, energy-based device (EBD), suction and endobag (Fig. 5). Procedures are offered with IONM. Intermitted IONM is performed according to the standards of equipment set-up, induction and maintenance of anaesthesia, correct tube positioning verification tests, electromyography (EMG) findings and standardised technique (V1, R1, R2, V2). Vagal nerve stimulation on both V1 and V2 is applied without nerve exposure by simply and gently pressing

Table 5
Preoperative preparation for TOETVA. Guidelines should be used as an adjunct to the proposed indications and contraindications to determine which patients should undergo total thyroidectomy versus thyroid lobectomy.

	Comments
Similar to open surgery	TOETVA patients are euthyroid at the time of the procedure
Informed consent	The advent of remote access approaches in thyroid surgery have increased the need for a detailed communication of risks, benefits and alternatives to achieve an informed consent.
Pre-operative laryngeal examination	Pre-operative RLN palsy is a contraindication for the transoral approach
Prophylactic antibiotic	Reports on transoral approaches to the palatopharyngeal junction, transoral resection of retropharyngeal lymph node metastases, and intraoral removal of submandibular glands in humans with negligible contamination rates of the access route and the operative field
CT scan	For eligibility criteria and careful study of anatomical planes
Dental care	The 3 vestibular incisions determine a new communication between the oral cavity and neck and a poor oral heath may contribute the ability of the oral microbiota to invade the body. Good oral and dental hygiene can prevent possible postoperative infective complications

the ball-tip stimulator on the space between the carotid artery and jugular vein and increasing the stimulation intensity to 3 mA. Continuous nerve monitoring in TOT is still under investigation.

Incisions

The first 10-mm incision is made at the centre of the oral vestibule, with a subsequent space created passing the mandibular area and submental space to the anterior neck and spread laterally using an electrical scalpel and Kelly clamp forceps (Fig. 6). A blunt-tipped 10-mm trocar is inserted in a 10- or 5-mm 30° laparoscope. Carbon dioxide (CO_2) insufflation pressure is set at 6 mmHg [29]. Two 5-mm trocars are inserted at the junction between the incisor and canine on both sides pointing down to the anterior neck under direct endoscopic vision (Figs. 6–8).

Air pocket formation

Electrocautery and blunt dissection with mosquito and Kelly forceps are then used for the mandible. Once the periosteum is identified through the midline incision, the neck is injected with 1:200,000 epinephrine-saline mixture for hydrodissection of the subplatysmal plane [29]. The working space is created beneath the subplatysmal layer via the oral vestibule through the premandibular space by using a straight vascular tunneler, low pressure CO_2 gas insufflation (6 mmHg) and EBD (Fig. 9). The superior border is the larynx, inferior border is the suprasternal notch, and lateral borders are the anterior and medial borders of both sternocleidomastoid muscles. In lobectomy and bilateral procedures, the dissection is laterally extended to the medial border of the sternocleidomastoid muscle on both sides [29]. The whole procedure and operator's view are craniocaudal. The left lateral port with the Maryland forceps, the right lateral port with the EBD, the central port with the endoscope (5 or 10 mm, 30°, down facing). EBD is used for creating the working space and the dissection and division of tissue and vessels. An external hanging central neck suture for retraction is routinely applied. Thus, the working space is created and maintained by mechanical lifting and CO_2 insufflation, which provides an excellent endoscopic view during the operation. The strap muscles are divided and retracted by cutting the midline linea alba cervicalis and deep fascia. For better exposure, the strap muscles are retracted laterally by an external hanging suture [29].

Thyroidectomy

Once all the instruments are properly docked, the median raphe of the strap muscle is divided, and the operative field is exposed from the thyroid cartilage to the sternal notch. Then, the Delphian lymph nodes and/or the pyramidal lobe are resected to clearly identify the cricothyroid muscles and cartilage surface. The thyroid isthmus is divided to expose the trachea, and the strap muscle is dissected from the thyroid lobes' surfaces. The middle thyroid vein and superior thyroid artery and vein are ligated as

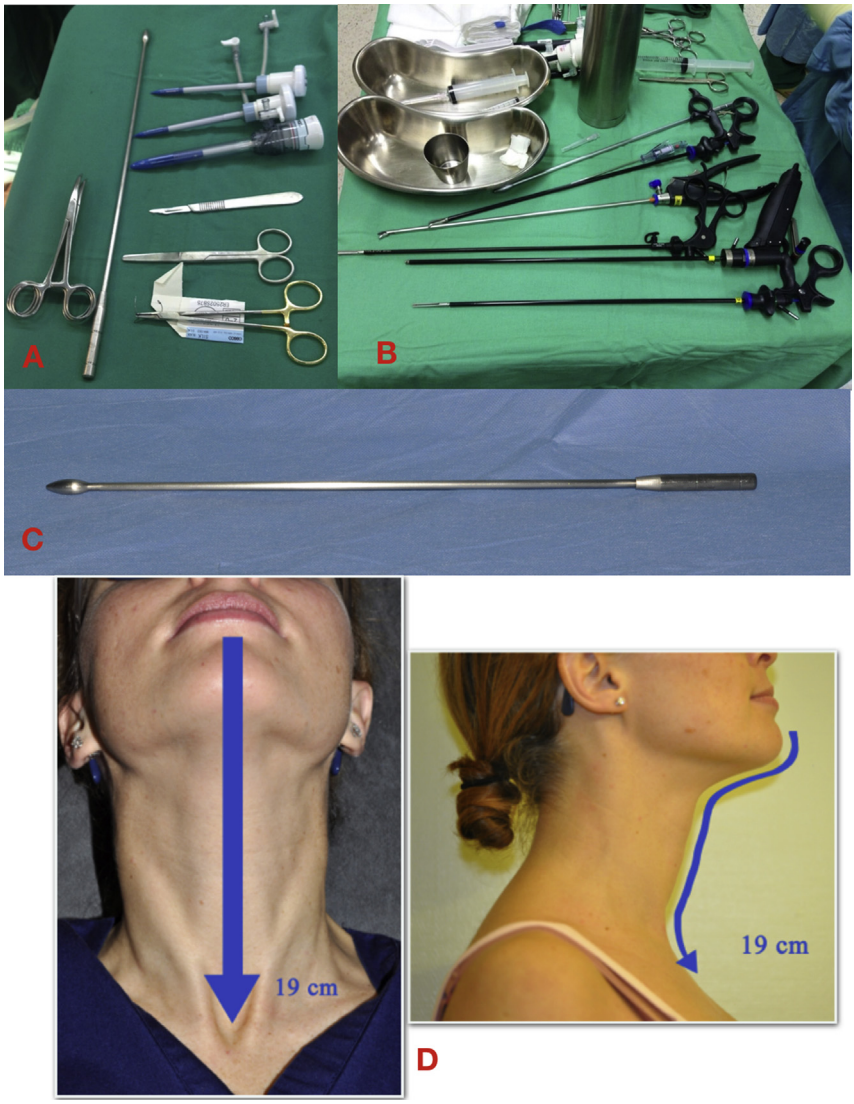

Fig. 5. (a,b,c,d). Equipment is the main part for TOETVA success. (a, b) TOETVA applies the basic instrument of endoscopic and conventional set, which may decrease cost compared with other remote access techniques and robotic procedures. Surgeon must consider using (i) perfect high quality vision and exposure, (ii) seal and cut (haemostasis) instruments, (iii) dissecting tools and (iiii) complementary devices (nerve monitoring), specimens removal. (c) The blunt dissector is a metallic stick with an olive at the end and promotes progressive gain in subplatysmal space enlarging the operative field. (d) Endoscopic instruments and energy based devices need to be longer than 30 cm considering the length of the neck, the passage in the trocars and the grip.

close to the thyroid as possible. During upper pole dissection, the external branch of the superior laryngeal nerve is preserved [29] (Table 6). The upper pole of the gland is lifted up, and we could easily identify the RLN, as its insertion to the larynx lies downwards parallel to the trachea in the trache-oesophageal groove. RLN exposure and nerve dissection use the craniocaudal approach (Fig. 10). The upward lifting traction of the thyroid lobe should be maintained during Berry's ligament dissection to safely identify and trace the RLN. Cutting this artery and vein should be performed close to the gland, with subsequent removal of the rest of the Berry's ligament [29]. The Berry's ligament is carefully divided while avoiding damage to the recurrent nerve. All parathyroid glands are identified and

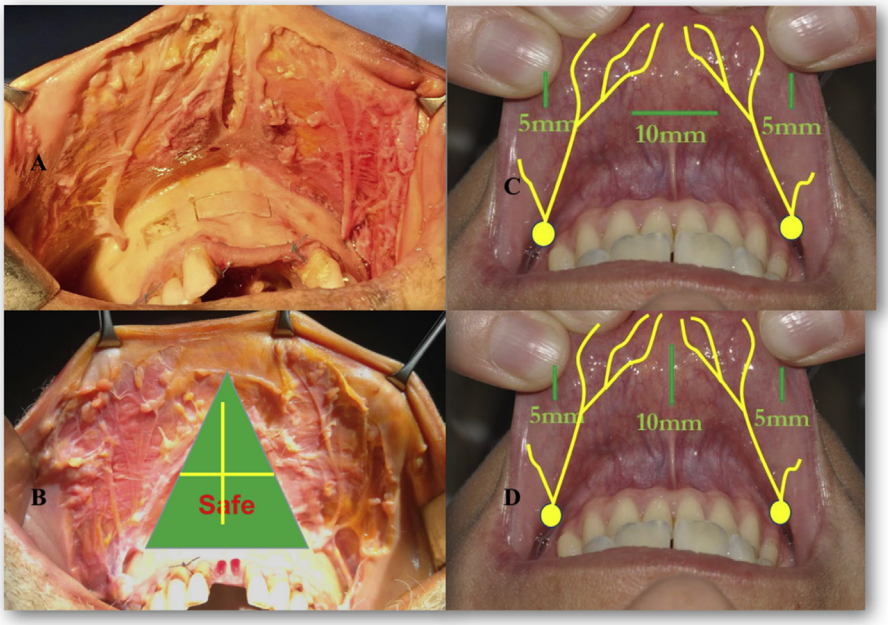

Fig. 6. (a,b,c,d). Location of the intraoral vestibular incisions for TOETVA. (a, b) Anatomical cadaver dissection of the mental nerve (MN). The green triangle is the safety area where the branches of the mental nerve rarely run. (c,d) The central incision is 1–2 cm in length and is placed beyond the cranial aspect of the buccal-mandibular frenulum, while two lateral 5 mm incisions are made at the lateral-anterior most aspect of the oral commissure in the mucosal border to avoid mental nerve injury and instrument collision. The midline incision may be parallel (c) or perpendicular (b).

preserved (Fig. 11). The specimen is removed using an endobag through a 10-mm incision and sent for pathology (Table 7). After complete thyroid removal, the operative field is irrigated with a saline solution, and meticulous haemostasis is achieved (Table 8). Contralateral thyroidectomy is accomplished only if the RLN EMG signal of the first side is preserved. If surgical drain is required, a 5-mm incision is created in the axilla and tunnelled up to neck. Correct drain placement is guaranteed by an endoscopic view [29] (Table 9). The strap muscles are reapproximated. The oral vestibule surgical wound is closed using running 4.0 absorbable sutures (Fig. 12).

Postoperative care

No dressing is required. Oral antibiotics and mouthwash 3 times per day are prescribed for 5–7 days. The patients start a soft diet in the same evening of the surgery on day 0. They are mobilised from bed after 4 h postoperatively. Additionally, they can take a shower in the evening and men can shave. Sunbathing is allowed on the following weekend. Hospital discharge is based on the common rules of the thyroid surgery—after careful evaluation of the surgeon and endocrinological and anaesthesiologic specialist and serum calcium dosage and after neck, mouth and laryngoscopy examination (Table 10).

Limitations of TOETVA: introduction of transoral robotic thyroidectomy (TORT)

Endoscopic thyroidectomy, regardless of the approach type, has its limitations due to its two-dimensional visualization and rigid instruments. Endoscopic rigid instruments in TOETVA can only produce linear movements and are unable to filter out the surgeons' natural tremors during the procedure [11,12]. These issues become a great challenge when precise dissection is required in a confined neck workspace. In addition, the two-dimensional endoscopic camera is operated by an

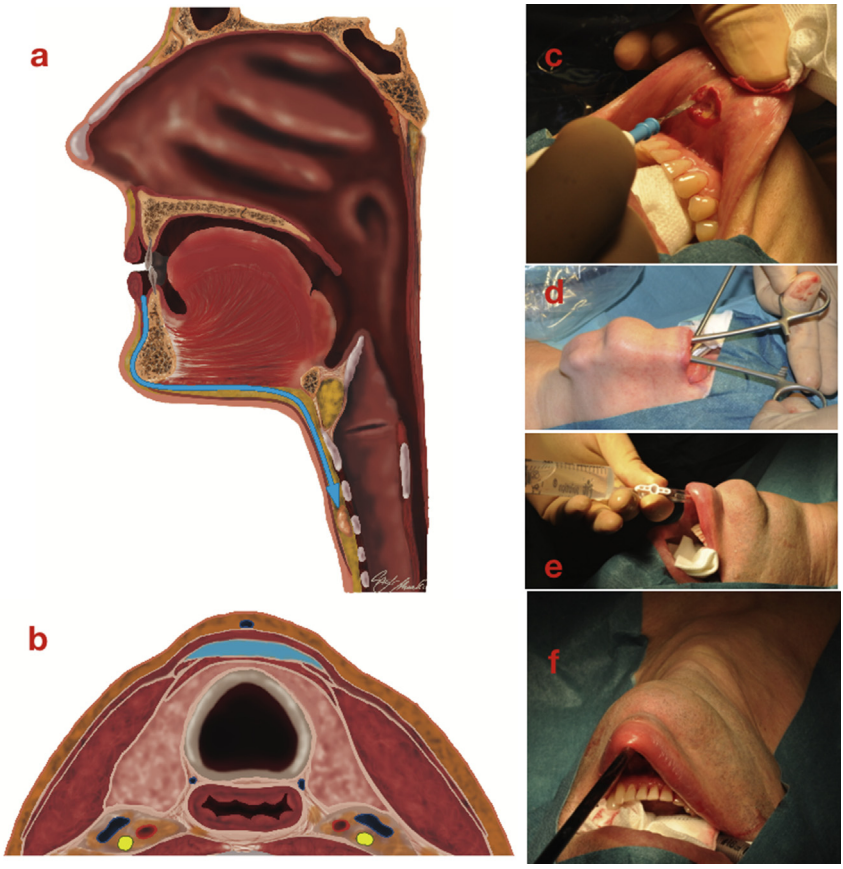

Fig. 7. (a,b,c,d,e,f). Route to the achievement of the working space. The working space is created beneath the subplatysmal layer (a,b) via oral vestibule incision (c), through premandibular space (d) by using hydrodissection (e), straight vascular tunneler (f).

assistant surgeon, making visualization field control even more difficult. Another limitation is that the specimen in TOETVA has to be removed through the intraoral midline incision [11,12]. As described by the authors, thyroid specimen less than 2–3 cm can be removed via the intraoral midline incision [36]. However, if the specimen is larger or hard in consistency, retrieving the specimen becomes more difficult, and the tissue needs to be fragmented before it can be removed through the midline incision [36]. Such tumour manipulation may cause capsule disruption which increases the risk of tumour spillage into the operative field [36]. TORT, which is the introduction of robot technology in thyroidectomy in combination with the transoral vestibular approach provided new solutions. With its robotic articulating instruments, surgeons can perform three-dimensional movements with 7° of freedom which enables more precise dissections around the critical structures (Fig. 13). The articulated movements of the EndoWrist allow complete resection of the pyramidal lobes or superior pole of the thyroid gland. The benefits of articulation further stand out in male patients where the instruments can easily curve over the acutely angled thyroid cartilage and steadily retract the thyroid tissue. In addition, the surgeon's view under a robotic camera is better enhanced with a high-resolution, three-dimensional display which is fully controlled by surgeons. In TORT, no modifications to the standard TOETVA technique are required, except for the additional fourth robotic arm through the axilla. The supplementary arm through the axilla port placement enables counter traction of the perithyroidal and perineural tissues, which enhances fine and precise dissection. In addition, additional axilla incision can be used for thyroid tissue removal. With a small extension of the incision followed by sufficient

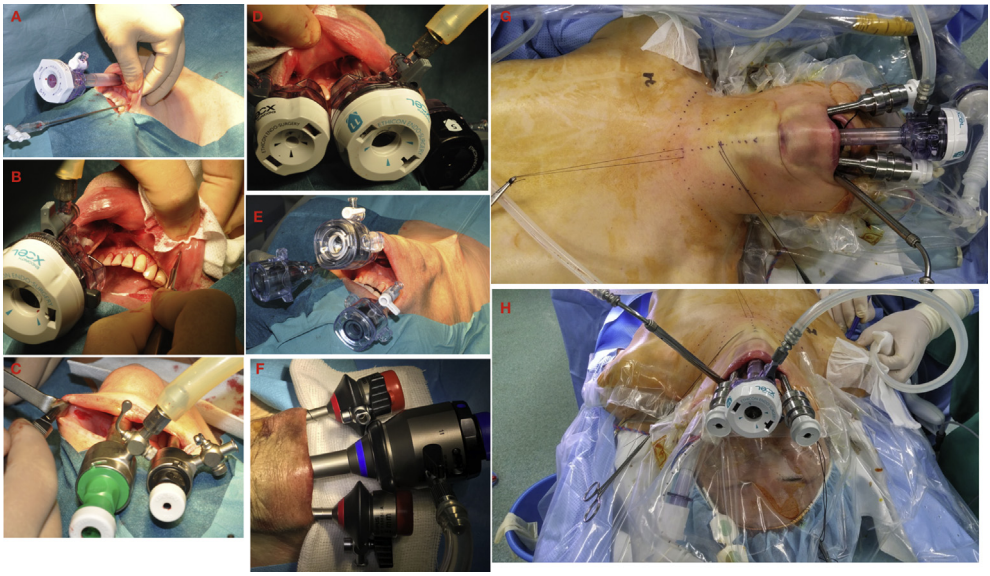

Fig. 8. (a,b,c,d,e,f,g,h). Port insertion (a,b,c). Three trocars are employed for TOETVA. One, central 10–12 mm trocar and two 5 mm trocars. A blunt-tipped 10-mm trocar is inserted for a 10 or 5 mm 30° laparoscope. Port can be reusable or disposable. Spiral port better are preferable because of less displacement rate. Trocars need to have a small, not bulky head. Sigle port technologies are under evaluation. (g,h) Port insertion for transoral robotic thyroidectomy.

subcutaneous tunnelling and dissection, large tumours can be easily removed without fragmentation. Hence, there is no risk of tumour spillage.

Challenges of TORT

Table 11 compares the advantages and disadvantages of the 2 transoral vestibular approach techniques: TOETVA and TORT. Despite promising solutions to the transoral vestibular approach, there are still few obstacles to overcome in TORT. A surgeon can directly receive real-time tactile feedback with laparoscopic instruments in TOETVA during the operation; however, robotic console in TORT cannot provide such tactile feedback. Hence, surgeons require more experiences with robotic surgeries in performing TORT. Moreover, TORT requires additional time for robot docking and, therefore, takes relatively longer operation time compared to TOETVA. Furthermore, while conventional laparoscopic instruments are readily available in most hospital facilities nowadays, access to robotic systems is still limited. Hence, the instruments are not readily available to many surgeons. Robotic surgery is still more expensive. For instance, the average operation fee for TORT is 3–4 times higher than that of TOETVA. While insurance coverage and/or government healthcare approval may vary among different countries, it is inevitable that robotic surgery still imposes a greater financial burden to the patients. Nonetheless, with the increasing number of companies investing and competing in robotic surgical system production and development, such financial barrier may diminish over time in the future.

Benefits of the transoral approach

Cosmesis

The main benefit and indication of TOT is a good cosmetic appearance (Table 12, Figs. 4 and 12). Given the pre-eminence of thyroid surgery in young female patients, consideration should be given to reduce to the smallest as possible the invasiveness of the surgical procedure, secrete scars, that is

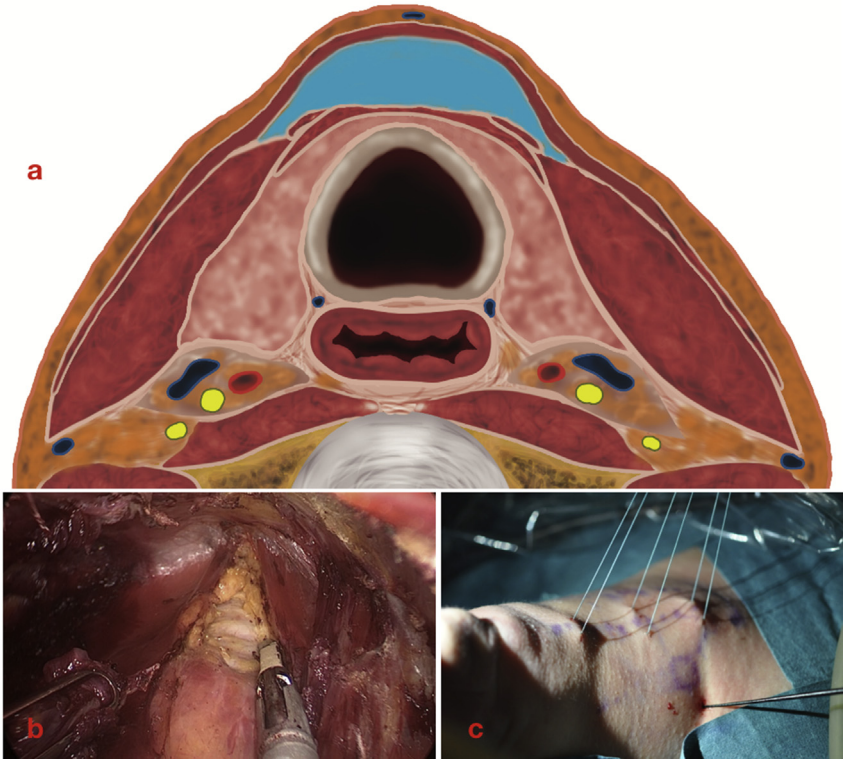

Fig. 9. (a,b,c) Creation of working space (a, b). The superior border of the air pocket is the larynx, inferior border is the suprasternal notch, and lateral borders are the anterior and medial borders of both sternocleidomastoid muscles. Laterally, both for lobectomy and bilateral procedure, the dissection is continued up to the medial border of the sternocleidomastoid muscle on both sides. An external hanging central neck suture for retraction is routinely applied (c). Thus, the working space is created and maintained by mechanical lifting and CO_2 insufflation, which provides an endoscopic view during the operation.

improve cosmesis and the appearance of patient after surgery [30]. Cosmetic concerns, discussions and request, debated are a matter of some uncertainty, difficulty and frequently demanded from young women and men and their partners or husbands, in the day life activity and work [31]. Conventional thyroidectomy includes a transverse cervical incision, at least 3-cm long, which determines an appreciable mark left by the healed wound [32]. TOT creates no visible incision in the skin, neck and/or

Table 6
Strategies for safe upper thyroid pole management (external branch of the superior laryngeal nerve EBSLN and superior thyroid vessels). The view of the upper thyroid pole is limited in TOT due to the cranio-caudal approach, the conflict between the mandible and the trocars.

- Use a 5 mm/30° endoscope (for ubiquitous port side use)
- Retract ports up to the limit with the lower edge of the jaw, for better vision
- Carefully engrave the sternothyroid muscle cranially
- Tract the thyroid upwards and laterally (Jolles space)
- Use neural monitoring for EBSLN mapping
- Tie individually the superior thyroid vessels branches
- Secure vessels with clips and/or energy based devices
- In case of retraction and bleeding of the upper vessels, compress the lower edge of the jaw corner, from the outside, down, to stop bleeding and stretch the upper thyroid vessels downwards for haemostasis

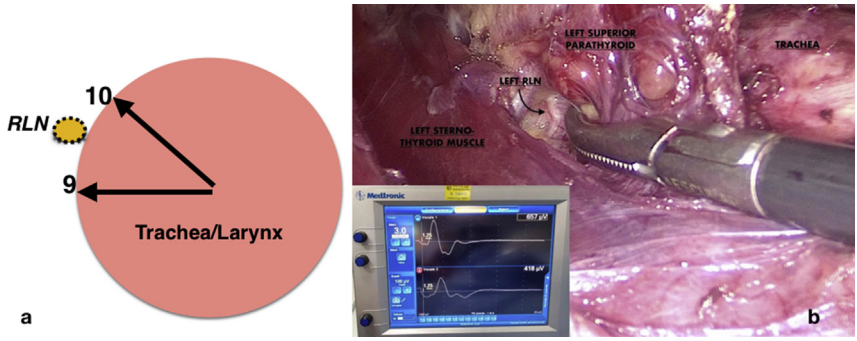

Fig. 10. (a,b). Identification of left recurrent laryngeal nerve identification. In open thyroidectomy, the RLN can be identified 2 different ways: initially caudad from the inferior thyroid artery and then traced to the cephalad (bottomup) or initially from the RLN at the insertion point and then traced caudad (top down). (a) For TOETVA, it is easier to dissect the RLN first at its insertion (the ideal plane at 9–10 o'clock (right, 2–3 o'clock) of laryngeal entry point) and then follow from top down. (b) Neural monitoring is a useful device for nerve mapping. The dissecting endoscopic instrument is adapted as a stimulating device and connected to the monitoring system.

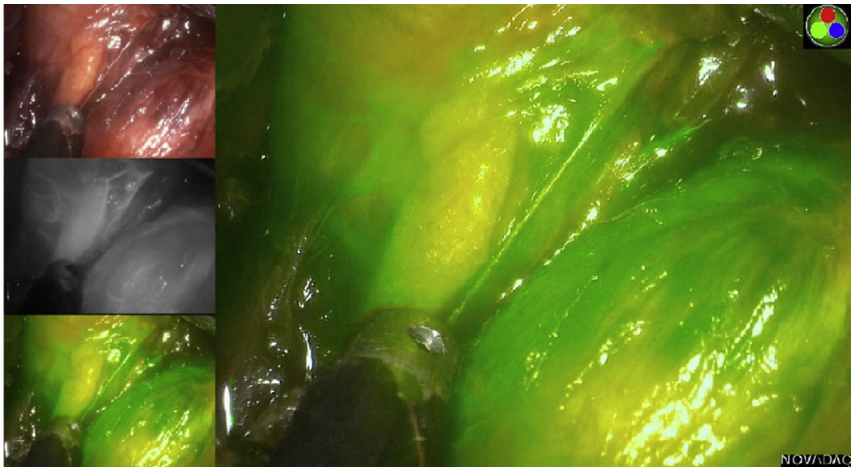

Fig. 11. Intraoperative view of the left superior parathyroid gland identification. The use of indocyaninegreen is under investigation in TOETVA in terms of its use for locating the parathyroid glands and/or proofing are viable glands.

other areas of the body compared to the conventional and other endoscopic thyroidectomy [33]. The three surgical incisions are weaved in the vestibular, lower lip. Consequently, there is no physical or physiological complication such as keloid and hypertrophic scar formation, contracture formation and dehiscence [30–33].

Minimally invasive procedure

TOT is a minimally invasive procedure because its vestibular access is proximal to the thyroid gland and the length of dissection guarantee less operation [34,35]. The route to the anterior neck is closer and shorter than that in the axilla, breast or retroauricular area (Figs. 2, 4 and 7). The transoral approach respects surgical anatomical subplatysmal planes. Flap dissection is similar to that of conventional surgery. The other potential benefits of NOTES are decreased postoperative pain, less need for post-operative analgesia, shorter hospital stay and faster recovery. Additionally, NOTES may have several

Table 7
Strategies for specimen removal.

- The major advantage of TOETVA small hidden incisions, must be balanced with the need to remove and preserve specimens that may be larger than the 10–20 mm port site
- Specimens vary in dimensions, physical characteristics and ease of extraction
- Special consideration apply to specimens that may be malignant. Improper removal may lead to tumor dissemination
- Inserting the specimen into an endobag is mandatory whether the nodule is benign or malignant. Endobag is inserted individually, already detached from the stem, from the 10 mm port. Endobag is completely open, lying in the airpoket, with the edge of the wire clearly 360° visible. Then a forceps keeps the endobag open, the other reaches the specimen under endoscopic vision. When withdrawing the endobag, make sure that the wire does not attach to the nearby anatomical structures (muscles) or the lateral 5 mm ports. Close the endobag under endoscopic vision. The specimen is removed using the 10-mm incision and sent for pathology
- The thyroid can be extracted by using sponges, forceps, and a 'push and pull technique' without rupture of the thyroid capsule and endobag
- To avoid extending the vestibular incision for larger malignant nodule (>20 mm), an axillary hybrid technique can be considered. This entails adding one axillary incisions to access the created cavity and aid in the dissection and subsequent specimen extraction by enlarging the incisions. This technique can be adopted to extract larger malignant nodules (>20 mm) without fragmenting the specimen at the same time avoiding mental nerve injury

Table 8
How to handle and prevent intraoperative bleeding. In the case of postoperative bleeding with respiratory distress, we recommend an immediate cervicotomic approach. Re-opening the vestibular incisions must be performed with extreme caution for safeguarding the airways.

- Most common cause of conversion
- Do not be frightened, keep your concentration
- Try to identify bleeding site and stop more dissection
- Endoscopic 5 mm gentle aspiration and irrigation device
- Try to use clips
- If EBD use, be aware to RLN distance
- External compression from the skin for haemostasis
- Conversion to open surgery (or minimal invasive video-assisted procedure)

Table 9
Strategies for drainage.

- After complete removal of the thyroid, the operative field is irrigated with saline, and meticulous hemostasis is controlled and achieved
- Strap muscles are re-approximated
- Lobectomies usually require no drainage
- Few total thyroidectomy need drainage
- Clots and liquids are removed (a) before port removal with the endoscopic aspirator and (b) after port removal by caudo-cranial compression with leakage of liquids from vestibular incisions
- If surgical drain is required, this is placed by adding a 5-mm incision into the axilla and tunnelled up to neck
- The correct placement of drain is guarantee by endoscopic view
- The type of drainage is dictated by the individual surgeon habits

advantages in specific subpopulations. It may provide an easy alternative access to the neck in morbidly obese patients, in whom other endoscopic access can be difficult because of wall thickness.

TOT preserve bilateral gland exploration

TOT is through a central median approach; thus, it provides the required secure bilateral view and exposure of the thyroid gland. The two-sided procedure can be safely performed without additional incisions (Fig. 4). Apart from the other endoscopic and robotic-assisted approaches that have lateral remote access (as in the axilla or retroauricular), the TOT approach provides a midline access and main laid-line exposure to the isthmus, the right and left thyroid lobes in their completeness (superior and

Fig. 12. (a,b,c,d). Outcomes of TOETVA. TOETVA results in ideal cosmetic outcomes because of scarless access, with the incision hidden in the oral vestibule. (a) Vestibular incisions immediate after surgery. (b) Vestibular incisions at 6 weeks after surgery: the oral mucosa heals rapidly. (c) Appearance of the neck immediate after surgery. (d) At 2 weeks after surgery: the ecchymoses from port placement and sub-platysma dissection disappeared.

Table 10
TOETVA postoperative care.

Oral Antibiotics for 5–7 days. Some Authors suggest only intraoperative prophylaxis
No dressing is required. Some Authors suggest a compression dressing applied to the anterior neck for 12–24 h
Mouthwash 3 times per day for 5–7 days. Brushing teeth from 1st day post-op.
Oral diet on day 0 postoperatively (evening)
Patients are mobilized from bed 4 h postperatively
Patients can take a shower and man shave on day 0 postoperatively (evening)
Patients can sunbathe on the following weekend

inferior pole, posterior gland), pyramidal lobe, 2 inferior and superior laryngeal nerves, parathyroid glands and lymph nodes in the central compartments, level 6 around the RLNs, trachea and oesophagus [35]. Central compartment inspection and dissection with complete lymphadenectomy are described and are feasible and safe [34]. TOT represents an appreciable opportunity over the other remote techniques (transaxillary bilateral axillo-breast approach), wherein the approach to the contralateral thyroid lobe, central compartment lymph nodes and pyramidal lobe is actually demanding even for the experienced surgeon [35]. The view from the 30° HD endoscope during the transoral approach is cranial to caudal, and this is a well-acquainted frame for the surgeon who is routinely involved in conventional thyroid surgery for identifying the laryngeal nerves and parathyroid glands and provides excellent exposure, allowing a complete central neck dissection [34,35].

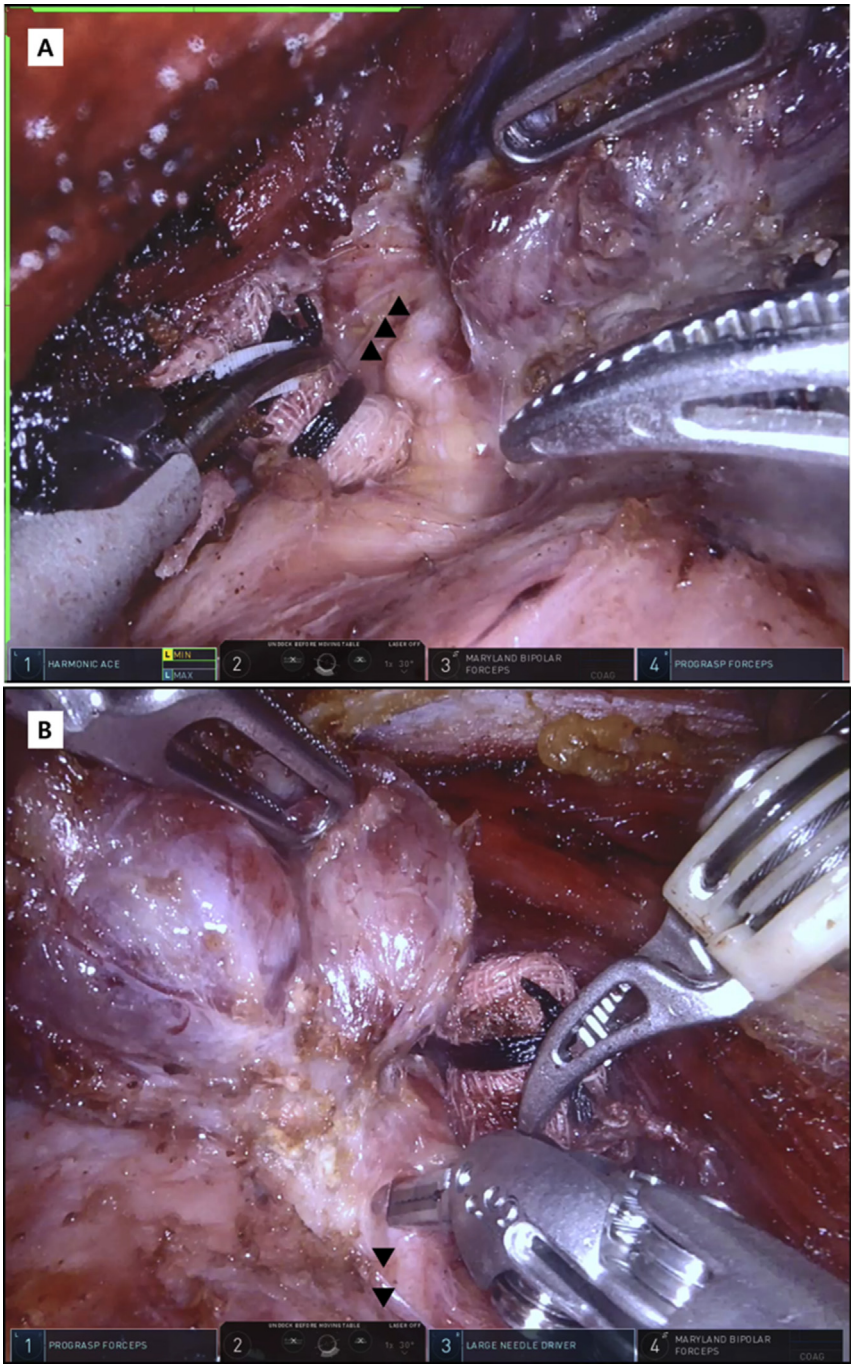

Fig. 13. (a, b). Intraoperative view of Transoral Robotic Thyroidectomy (TORT). The recurrent laryngeal nerves are marked with black arrow heads. (a) Left lobectomy. The left thyroid lobe is lifted upward by the right axillary ProGraspTM while dissection continues on with the Maryland forceps through the right lateral port. Note here that the Harmonic® scalpel is inserted through the left arm. (b) Right lobectomy. The right thyroid lobe is lifted upwards in medial direction by the left lateral ProGraspTM, and the dissection is proceeded with a needle driver from the right lateral arm and the Maryland forceps from the right axillary arm.

Table 11
Comparison between TOETVA vs TORT.

	TOETVA	TORT
Cost	Low	High
Accessibility	High	Low
Operation time	Shorter	Longer
Tactile feedback	Yes	No
Instrument articulation	No	Yes
Instrument movements	2-dimensional, linear movements only	3-dimensional movements with 7-degrees of freedom
Tremor filtering	No	Yes
Vision	2-dimensional endoscope	Dual-lens camera 3-dimensional, high-resolution
Vision control	Assistant control	Surgeon control
Patient access	3 intra-oral ports	3 intra-oral ports *plus* Additional axillary ports
Counter-traction	Often unavailable	Readily available
Specimen removal	Through intraoral midline incision; large (>4 cm), hard tumors have to be fragmented	Through axillary incision; specimen can be removed intact with adequate incision extension and subcutaneous dissection

Table 12
Transoral approach advantages.

- The concept of NOTES
- Optimal cosmesis with no visible cutaneous scarring
- Free of neck wound complications
- Minimal invasive nature
- Natural identification of the sub-platysma plane
- Bilateral neck exposure
- Possible central lymph node dissection (level 6 and 7)
- Reproducible and standardised technique
- Feasible with both conventional endoscopic and robotic instrumentation
- Costumized postoperative course

Completeness of resection

The oncologic efficacy of endoscopic thyroid procedures has been an issue of debate. Recently, the authors assessed the residual thyroid tissue in the central compartment by I-131 uptake and the ablative doses of required radioiodine postoperatively in TOT [11,12]. In all reported procedures, malignant thyroid lesions were excised with negative margins [11,12]. Radioiodine uptake in the thyroid bed was comparable to open thyroidectomy procedures and consistent with previous endoscopic reports [11,12]. The dose of delivered radioiodine was similar in patients treated by open thyroidectomy and reported elsewhere [11,12]. Additionally, thyroglobulin levels were undetectable in patients with a malignant disease following TOT and radioiodine ablation. Lymph nodes adjacent to the thyroid lobe could be intentionally removed and histopathologically examined for metastatic disease in both endoscopic and robotic TOT. Central compartment lymph node dissection (both level 6 and 7) during TOT was safely completed with clear identification of the RLN and parathyroid glands. Although the biological and clinical significance of metastatic disease remain unclear, successful lymph node removal from the central compartment demonstrates that TOT can provide a comparable degree of histopathologic information as conventional open thyroidectomy procedures. Cumulatively, these findings indicate that TOT procedures are safe and oncologically complete for selected low-risk or intermediate-risk thyroid cancer patients. Longer term follow-up is obviously necessary to document similar outcomes as open thyroidectomy. However, the indolent nature of thyroid malignancy prevents any informative follow-up data from being available until these patients have been clinically followed for at least 10 years.

Reliable postoperative course

The postoperative course of TOT is reliable, customised and steady (Table 10). No dressing and wound care are required for TOT. Oral antibiotics and mouthwash 3 times per day are prescribed for 3–5 days [29]. Patients are mobilised from bed after 4 h postoperatively [29]. Most patients start a soft diet on day 0, on the same evening of the surgery [5]. Patients can shower in the evening and men can shave. Sunbathing is allowed on the following weekend [29]. Hospital discharge is based on the common rules of the thyroid surgery – after careful evaluation of the surgeon and endocrinological and anaesthesiologic specialist and serum calcium dosage and after neck, oral vestibule and laryngoscopy examination.

Limits, risks and challenges

Transoral thyroid surgery represents the latest technological advancement in the approach to minimally invasive endocrine surgery. News headlines quoting claims such as 'Thyroidectomy through the mouth may be an option for same patients' have been brandished in the press [37]. However, it is clear that conventional open thyroid surgery is here to stay. TOETVA advantages have been speculated and demonstrated in prospective studies, but so far, these procedures are still limited to a minority of patients [13–27]. Several critical issues, including the safety of the transoral approach and whether it will provide significant patient benefit in postoperative outcomes compared with open surgery and other endoscopic procedures, must be resolved before the new technique is successfully and responsibly introduced in clinical care (Table 13). Additionally, it is recognised that the early use of this approach by surgeons who might be relatively inexperienced in the particular skill sets required might lead to novel and/or serious complications, which should definitely be avoided during the start of this concept. There are several potential challenges to safe introduction of TOETVA (Table 13). Although the relative importance of these challenges is debatable, there is unanimous consensus among experts on the critical nature of the need for adequate training and prevention of novel complications (i.e. mental nerve [MN] injury) and infections and understanding the physiologic consequences of TOETVA (Tables 13–15).

TOETVA should provide all of the advantages of the other endoscopic surgeries and NOTES concept. Certainly, there are significant differences between TOETVA and the other NOTES approaches (transgastric appendectomy, transvaginal cholecystectomy, cancer staging, percutaneous enteral gastrostomy salvage). Wound infection, incisional hernias and postoperative adhesions in abdominal surgery are common surgical complications and are eliminated with NOTES. However, these sequelae rarely belong to thyroid surgery. The advantages of NOTES for thyroid gland excision might still be less impressive than those in abdominal surgery.

Novel complications

The vestibular approach exposes the patient to new possible complications (Table 14). These new risks are rarely encountered in open thyroidectomy. When comparing the data of overall complications between open and TOT surgery, there are 10% more novel complications, although they are transient. For example, surgeons must achieve perfect knowledge of the course of the MN. MN is a sensory nerve which provides sensation to the front of the chin and lower lip and buccal gingivae of the mandibular anterior teeth and premolars. The nerve emerges at the mental foramen in the mandible and divides beneath the depressor anguli oris muscle into 3 branches: (a) 1 descends to the skin of the chin and (b) 2 ascend to the skin and mucous membrane of the lower lip. MN injuries can be transient or permanent and can result in decreased lower lip sensation and the inability to sense hot liquids (Table 15). The prevalence of MN injury is between 1 and 5% [12–27]. Although this complication was observed during the early phase of operative development, it appears to have been significantly reduced by moving the 5-mm lateral vestibular incision sites anteriorly and 10-mm medial incision as shown in Fig. 6.

Table 13
Potential challenges and research agenda to clinical application of TOETVA.

- Requires specific patient and surgeon candidacy
- Unable to perform ideal 4-port transoral operation (i.e. 4th arm for retraction)
- Instrumentation, equipment and materials not fully developed
- Naso- vs. oro-tracheal intubation argument
- Air pocket set up time
- Longer overall operative time
- Spatial orientation
- Unstable CO_2 and flap maintenance
- Understanding untoward physiologic consequences of oral entry
- Antibiotic prophylaxis vs. extension of treatment
- Vestibular infection/abscess management
- Bacterial contamination and prevention of neck
- Prevention and management of mental nerve injury
- How to handle intra- and postoperative bleeding control
- Management of iatrogenic and other complications
- Completeness of resection (oncological concern)
- Conversion percentage
- Standardized intermittent neural monitoring (application of trouble shooting algorithms)
- Continuous neural monitoring (vagal nerve probe placement)
- Pain classification
- Specimen extraction
- Cost-effectiveness
- Training

Morbidity

TOT will always be more technically demanding than open surgery. The endoscopic approach determines a modification in the surgeons' approach to neck structures (Table 16). The surgeons cannot apply a new endoscopic or robotic approach as TOT without perfect govern of the neck structures, laryngeal nerves, parathyroid glands, and trachea. This would be in contrast with the commonly performed routine open surgery. It would be a step back. TOT has to be in the same secure area of open procedure. A direct comparison of open thyroidectomy or other endoscopic procedures with TOT is rare. This may be because most centres would adopt a particular approach as their preferred choice and because it offered a choice for patients. Cohorts usually have relatively young and predominantly female patients; thus, most patients prefer not having a visible neck scar following surgery. However, based on a series of routinely performed postoperative laryngoscopic examination, the temporary and overall RLN injury rate is comparable to open procedures [12–27]. These findings require further validation by the other surgeons in different centres or in a multicentre, prospective study. No conclusions can be made on the percentage of hypocalcaemia after TOT, as most studies include hemithyroidectomies with a prevalence of 80–85% in some cases [12–27]. Neck and swallowing pain scores during TOT were consistent to those found in open procedures [12–27]. However, it is necessary to make a detailed pain classification for TOT, since the patient may experience a new pain (i.e. lower lip and chin pain that are not present in open surgery).

Operative time

In all published series, the operative time in TOT was significantly longer than that in open surgery because such procedure requires port placement and flap dissection. However, the operative time was shorter compared with the other endoscopic approaches such as the retroauricular and axilla [12–27]. Shulutko et al. evaluated the time of the oral approach to the neck, in cases of different shape of the mandible. The operative time was longer when the mandible has a long and narrow basal arch

Table 14
Auditing TOT specific complications, mechanism and prevention. The rate of these complication is under investigation.

Complication	Consequence	Mechanism	Prevention and management
Mental nerve injury	0–3.5% rate Transient or definitive, monolateral or bilateral sensory deficit of emi-lower lip and chin Permanent lesions present numbness area of small coin dimensions, below the lip	See Table 15	New refined vestibular incisions to prevent nerve injury have been proposed, moving A) the lateral 5 mm incisions anteriorly and laterally, B) the 10 mm in the green area demonstrated in Fig. 6 Management of mental nerve injury is not standardised
Bruise over zigoma	After a few days, the blood under the skin reabsorbs	Accidental compression of zigoma by ports or endoscopic instruments	Protective sponge application over zigoma
Chin flap perforation	Skin closure Difficulty in maintaining CO_2 inflation Scar	Wrong axial (perpendicular) vestibular dissection with electrocautery	Careful axial (parallel) vestibular dissection with blunt Mosquito forceps. The Mosquito tips should be directed inferiorly
Mouth commissure tearing	Contour edema Trismus	Excessive oral lateral port movements when A) upper flap dissection, B) superior pole dissection, and 3) midline closure	Oral mucosal protection sutures + Plaster application over commissres
Skin dimpling in midline of lower chin	Spontaneous recovers in 1–2 weeks	Compression of mandible tip by integral middling trocar	Dedicated redesign instruments
Tearing of the inferior labial frenulum	Suture stitching	Vestibular midline incision too inferior Excessive oral midline port movement	Engraving done 5 mm above the frenulum
Carbon dioxide embolism	Severe adverse haemodynamic effects	Neck venus injury Excessive CO_2 insufflation pressure or duration	Low pressure CO_2 gas insufflation (6 mmHg), flow rate 15 L/min Flap lifted by skin suspension stitches (or suspension/retracting devices) End tidal CO_2 should be monitored for the entire operation
Neck scalding	Spontaneous recovers in 1–2 weeks	Absence or no overlapping of the emi-platysmal fibres in the midline of the neck Subcutaneous tissue poorly represented Endoscopic camera light too hot and/or energy based devices in contact with the overhead subcutaneous tissue	Careful flap and air pocket formation
Chin and neck adhesions	Wrinkles from neck and jaw area Loss elasticity of the skin Spontaneous recovery in 1–4 months	Flap dissection	Respect of the subplatisma plane of dissection Meticoluous haemostasis Suture of the midline strap muscles Anti-adhesives drugs Slight pressure,

Table 14 (*continued*)

Complication	Consequence	Mechanism	Prevention and management
			gyratory massage from the 5th postoperative day over the neck and chin Extension and lateralization movements of the head, with the mouth closed from 10th day postoperatively
Use of disinfectant above the chin and in the oral cavity	–	–	Be careful to use the disinfectant in the oral cavity Furthermore, pay attention to the drops of disinfectant that can fall into the eyes (protection) Remove excess disinfectant from the mouth Place gauze inside the oral cavity during the surgical procedure (useful for removing clots)

Table 15
Possible factors that might determine mental nerve (MN) injury. MN injury may be transient or permanent, unilateral or bilateral.

Dynamic issues
Incorrect vestibular surgical incisions
Erroneous vestibular surgical dissection
Imprecise port insertion
Inaccurate trocar removal
Duration of surgery (longer compression of trocars on the MN)
Port angle
Static issues
Port materials, consistency and constitution
Atraumaticity of trocar tip and canula
Trocar size
Anatomical variability of the MN course
Anatomical variability of chin

compared to that with a short and wide arch ($p < 0.0001$) [38]. In general, the length of hospital stay in TOT was similar to that in open surgery [12–27].

Learning curves and training

Another, and perhaps the most important, challenge for safe clinical use of NOTES is the development of effective training programs and credentialing guidelines. Learning curves refer to the number of TOT procedures performed before a surgeon has mastered a task. Mastery is achieved once certain parameters are met, including operating time, blood loss, complication and recurrence rates and conversion rate to open thyroidectomy. The number of procedures required to achieve such

Table 16
Surgeon approach to the RLN identification and exposure in different techniques. The surgeon who performs endoscopic techniques must be able to modify his surgical technique for laryngeal nerves dissection according to the approaches applied. Open surgery has more modes for RLN dissection than any other endoscopic procedures.

	Open	MIVAT	TOT	Areola	Axilla	Retroauricular
Cranial to caudal [a]	+	-	+	-	+	+
Caudal to cranial [b]	+	+	-	+	+	-
Lateral to medial [c]	+	+	+-	+	+	+-
Hybrid	+	-	-	-	+	-
Bilateral exposure	+	+	+	+-	+-	-

RLN: recurrent laryngeal nerve.
MIVAT: minimally invasive video assisted thyroidectomy.
TOT: Transoral thyroidectomy.
Hybrid: both a,b,c
[a] Cranial to caudal: RLN is identified and dissected from the laryngeal entry point.
[b] Caudal to cranial: RLN is identified and dissected from the thoracic outlet.
[c] Lateral to medial: The identification of RLN is carried out from medial to the carotid sheet to the tracheoesophageal grove.

competence varies greatly from surgeon to surgeon and from specialty to specialty. Previous endoscopic experience is a great advantage. For axillary or breast endoscopic approaches, the learning curve is 35–50 cases [39]. It has been postulated that 15 cases are required to achieve an expert proficiency level pertaining to Miccoli's technique [40]. Interestingly, the learning curve for TOT appears to be shorter than that for the remote endoscopic approaches, similar to the Miccoli's technique. [41,42]. Members of the study group have taken an initial step to expand participation of investigators interested in or already working on TOETVA from around the globe and have outlined first training courses. Proposed training programmes include knowledge-based didactic lectures and time spent in a skills laboratory with cadaveric training. Virtual reality simulators for TORT are currently under validation.

Instruments

Currently available instrumentation is inadequate for performing complex transluminal thyroid procedures. TOT issues include the lack of a multitasking platform (i.e. single port), number and size of access channels, inability to position and allow robust retraction and exposure (i.e. no fourth arm), inability to control insufflation pressures and energy-based smoke effect and inadequate suction/irrigation capabilities for such narrow neck air pocket. These problems can be resolved to some extent with scope-handling expertise and by dedicated redesign instruments. The importance of the 4 arms in TOT is manifested during robotic surgery. The ideal 4-port endoscopic/robotic thyroid surgery enables (a) counter traction of perithyroidal and perineural tissue, (b) gauze and cotton placement, (c) bipolar electrocautery, (d) large (tumour >2 cm) specimen removal and (e) further drain placement through the port tunnel and (f) enhances fine and precise dissection [12].

Intact specimen removal

In a recent study, the authors sought the appropriate nodular diameter in thyroid cancer to be removed in an intact status through the central incision of the TOETVA technique [36]. A total of 27 cases of thyroid nodules were operated using the TOETVA technique. Excluding 10 benign goitres, the specimens of 17 thyroid cancer cases were divided into intact (group T, $n = 7$) and fragmented (group F, $n = 10$), with a median nodular diameter of 18.35 and 30.30 mm, respectively. Receiver operating characteristic curve analysis revealed that the safest nodular diameter is 20 mm, with 100% sensitivity and 87.5% specificity (Table 7) [36].

CO_2 insufflation

The physiologic consequences of CO_2 insufflation have been extensively studied in endoscopic thyroid surgery [43]. However, it is unknown whether the CO_2 insufflation created during TOETVA will behave in the same fashion. Initial reports suggest the difficulties in maintaining a controlled pressure or required flow rates through endoscopes. [44,45]. Additionally, gas leakage can lead to loss of domain within the neck cavity. These technological hurdles must be resolved before NOTES can be successfully used in thyroidal clinical practice.

Summary

Thyroid surgery is evolving beyond current endoscopic and robotic approaches. TOT may represent the next phase of minimally invasive surgery, and early clinical experience shows that TOETVA and TORT are indeed possible among selected patients. Because of the immaturity of the instrumentation, early cases demand a technical virtuosity that probably precludes a widespread application of this approach. This balance will shift as enabling technologies are developed. Nevertheless, TOETVA will always be more technically demanding than open surgery. If definite patient benefits are documented, if the public begins to demand an 'incisionless' surgery or if both are the case, endocrine surgeons will need to master these techniques. This new endocrine surgery field may, in the near future, establish itself as a viable alternative to other endoscopic surgeries for the treatment of selected thyroid conditions.

Compliance with ethical standards

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Conflict of interest

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Ethical approval

This article does not contain any studies with human participants performed by any of the authors.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Author contributions

Dr Daqi Zhang and Dawon Park made equal contribution to the paper.
Conception and design: Gianlorenzo Dionigi, Hoon Yub Kim, Daqi Zhang, Dawon Park.
Administrative support: All authors.
Collection and assembly of data: Daqi Zhang, Dawon Park.
Data analysis and interpretation: Gianlorenzo Dionigi, Hoon Yub Kim.
Manuscript writing: All authors;
Final approval of manuscript: All authors.

Practice Points

- Additional surgical anatomical knowledge for transoral thyroidectomy (TOT) aids in understanding the oral cavity and how the mental nerve and neck spatial orientation can be protected.
- TOT is performed with a craniocaudal view and involves dissection of the thyroid and parathyroid glands and recurrent laryngeal nerve.
- The vestibular incisions determine a new communication between the oral cavity and neck. Pre- and postoperatively, the patients are asked to gargle with a chlorhexidine mouthwash. Amoxicillin/clavulanic acid is used as a prophylactic antibiotic.
- TOT uses the basic instruments in endoscopic and conventional sets.
- The transoral surgeon is required to have thyroid and endoscopic surgery expertise. This is similar to the general surgeon in retroperitoneal adrenalectomy and the ENT surgeon in sinus surgery.
- Three trocars were used—1 central 10- to 12-mm trocar and 2 5-mm trocars. The first 10-mm incision was made at the centre of the lower-lip oral vestibule, with a subsequent space created through the mandibular area and submental space to the anterior neck for a 5–10-mm, 30° endoscope. Two 5-mm trocars were inserted in the lateral vestibular incisions at the junction between the incisor and canine on both sides.
- A working space is created beneath the subplatysmal layer via the oral vestibule through the premandibular space. The upper border is the larynx; the lower border is the suprasternal notch, and the lateral borders were the anterior borders of the sternocleidomastoid muscles

Research Agenda

- Trials on the efficacy of TOT are needed to understand the untoward physiological consequences of oral entry.
- Dedicated instrumentation, equipment and materials are not fully developed.

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