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Transoral endoscopic thyroidectomy vestibular approach (TOETVA): indications, techniques and results

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Abstract

Introduction The Transoral Neck Surgery (TONS) Study Group was established at the 1st International Thyroid NOTES Conference in February 2016 with the intention of standardizing and refining thyroid NOTES techniques, including both transoral endoscopic and robotic thyroidectomy approaches. Herein, the authors report the modification of indications, preparation, and step-by-step explanations for operative techniques, as well as results and postoperative care for transoral endoscopic thyroidectomy vestibular approach (TOETVA).

Methods Between February 2015 and December 2015, a total of 200 patients comprising 8 males (4%) and 192 females (96%) underwent TOETVA using 3 laparoscopic ports inserted at the oral vestibule. Of these patients, 111 presented with single thyroid nodules (55.5%), while 66 patients had multinodular goiters (33%), 12 had Graves' disease (6%) and 11 had papillary microcarcinoma (5.5%). The CO_2 insufflation pressure was maintained at 6 mmHg. Each surgery was performed using laparoscopic instruments and ultrasonic devices.

Results TOETVA was performed on 200 consecutive patients. No conversion to conventional open surgery was necessary. Average tumor size was 4.1 ± 1.78 cm (1–10 cm). Median operative time was 97 ± 40.5 min (45–300 min). Median blood loss was 30 ± 46.25 mL (6–300 mL). Mean visual analog scale measurements were 2.41 ± 2.04 (2–7), 1.17 ± 1.4 (0–5), and 0.47 ± 0.83 (0–3) on the first, second, and third days, respectively. Temporary hoarseness and hypoparathyroidism occurred in 8 patients (4%) and 35 patients (17.5%), respectively. No permanent hoarseness or hypoparathyroidism occurred. Mental nerve injury occurred in 3 patients (1.5%). One patient (0.5%) developed a post-operative hematoma that required open surgery. No infection was identified.

Conclusion TOETVA was shown to be safe and feasible with a reasonable surgical duration and minimal pain scores. This approach shows promise for those patients who are motivated to avoid a neck scar.

Keywords Transoral endoscopic thyroidectomy · Thyroidectomy · TOETVA · Transoral · Endoscopic thyroidectomy · Transoral neck surgery

Open thyroidectomy is currently the standard surgery option for thyroid diseases. However, this approach leaves an unavoidably visible neck scar. Many modified techniques have been developed to reduce the size of the neck scar, including minimally-invasive open thyroid surgery [1, 2] and video-assisted thyroidectomy (MIVAT) [3]. Many of the alternative approaches for pure endoscopic thyroidectomy move the wounds to other parts of the body

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such as the axilla, breast, or post-auricular area [4–7]. However, cutaneous scars are still apparent. Further, these approaches require a large amount of flap dissection, which contradicts the notion that they are truly minimally-invasive.

Recently, Natural Orifice Transluminal Endoscopic Surgery (NOTES) for thyroidectomy was developed [8, 9]. This surgical technique completely avoids visible cutaneous scarring with an approach through the oral cavity. Two techniques have been described, including 1) a sublingual approach, which causes severe tissue damage with a high complication rate [10–12], and 2) an oral vestibular approach [13, 14]. The authors recently reported another refined transoral endoscopic thyroidectomy vestibular approach (TOETVA) in the first 60 human cases, which showed encouraging results with minimal complications [15].

After the 1st International Thyroid NOTES Conference was held in Bangkok, Thailand in February 2016, an international Transoral Neck Surgery (TONS) Study Group was established to further standardize and refine the thyroid NOTES technique, which includes both endoscopic and robotic instrumentation. To this end, the largest single-institutional cohort of TOETVA was assembled. The data have been reviewed in this report by members of a task force who have experience performing transoral thyroidectomy in their respective institutions. The first TONS Study Group report to describe modification of the indications, preparation, techniques, as well as postoperative care for TOETVA has been provided herein.

Methods

Perioperative preparation

All surgeries were performed by 3 surgeons at Police General Hospital in Bangkok, Thailand, a tertiary referral hospital. Patients were informed of their potential surgical options, which included conventional open surgery, TOETVA and other techniques of remote-access endoscopic thyroidectomy performed at the institution. Discussion of the various advantages and disadvantages of each approach, with consideration of the nature of the disease as well as their individual health issues was included in the informed consent process. Ultimately, patients elected the TOETVA approach if they were deemed appropriate surgical candidates. The study received approval by the ethics committee of Police General Hospital.

Inclusion criteria includes a thyroid gland of a diameter not exceeding 10 cm comprising (1) a benign thyroid nodule(s), (2) papillary microcarcinoma with no evidence of metastasis, (3) follicular neoplasm, or (4) well-controlled Graves' disease, as previously described [15]. In addition, we included grade 1 substernal goiters in the present study (above aortic arch). Early experience demonstrated that TOETVA can be done safely in patients who had previously undergone surgery or radiation at the chin and neck area. Moreover, patients with dental braces were no longer contraindicated (Table 1).

All patients had routine investigation including thyroid function tests, neck ultrasonography, and fine needle aspiration. Patient preparation was identical to that for standard open surgery. Dental evaluation by a dentist was only necessary for patients with severe oral hygiene issues. No routine dental examination was required.

Surgical technique

The patient was placed in a supine position. The shoulders were raised with sandbags and the neck was extended slightly. All patients were administered general anesthesia with nasotracheal intubation. The neck and lower face were prepped and draped from the lower end at the level of the sternal notch, the upper end at the level of the upper lip, and the lateral aspects of the neck. Pre-operative administration of 1.2 g of intravenous Amoxicillin with Clavulanic acid was injected 30 min before skin incision. The oral cavity was cleansed using 0.05% Hibitane in water. The surgeon stood at a point over and above the head of the patient, while the assistant and camera operator stood on either side of the patient's neck (Fig. 1).

Incisions and port insertion

The procedure was initiated with a 10 mm scalpel incision in the center of the oral vestibule just above the inferior labial frenulum (Fig. 2). This incision was made in a more anterior location compared to the previous technique [15]. Monopolar electrocautery was used to dissect in the central incision through the mentalis muscle down to the tip of the chin. Next, 30 mL of 1:500,000 adrenaline–saline solution (1 mg adrenaline in 500 mL NSS) was injected through a Veress needle through the incision site for hydrodissection down to the anterior neck area (Fig. 3A). This hydrodissection helps to elevate the subplatysmal plane off the strap muscles. A medium-sized Kelly clamp was passed through this incision to the level of the thyroid cartilage and gently spread to open a working space (Fig. 3B). The hydrodissection and Kelly clamp dilation helped to approach the correct plane between the platysma and strap muscles. Then, a blunt-tip tissue dissector was inserted through the incision and advanced in a fan-shaped manner in the subplatysmal plane above the strap muscles to widen the working space before insertion of a 10 mm trocar (Fig. 3C). CO_2 insufflation was then maintained at

Table 1 Previous and new indications for TOETVA

Previous indication[a]	New indication
Inclusion criteria: thyroid diameter <10 cm	Inclusion criteria: thyroid diameter <10 cm
Benign tumor	Benign tumor
Follicular neoplasm	Follicular neoplasm
Papillary microcarcinoma	Papillary microcarcinoma
Graves' disease	Graves' disease
	Substernal goiter, grade 1
Exclusion criteria	Exclusion criteria
Unfit for surgery	Unfit for surgery
Previous neck surgery	Unable to tolerate anesthesia
Radiation on the neck	
Unable to tolerate anesthesia	
Wore dental brace(s)	

[a] Previous indications are from a previous TOETVA report by the authors [15]

Fig. 1 Operative layout

6 mmHg with a flow rate of 15 L/min through the 10 mm central trocar. Stab incisions were then made with a scalpel for the lateral ports which were placed lateral to the canine teeth and on the lower lip to avoid injury to the mental nerve (Fig. 2B). This is in contrast to the previously described position (Fig. 2A) [15] which was more medial and inferior. Two 5 mm trocars were then inserted at the lateral incisions into the working space. The lateral trocars were maintained parallel to the 10 mm trocar (Fig. 4).

Initial dissection

After port insertion, an L-hook with monopolar coagulator and ultrasonic device were used to complete the working space (Fig. 5A). The boundaries of the subplatysmal working space were defined as follows: (1) inferior border at the sternal notch, (2) lateral borders at the edges of the sternocleidomastoid muscles, and (3) superior border at the thyroid cartilage. A 30-degree, 10 mm laparoscope was passed through the central port, with an L-hook cautery, ultrasonic device, and suction–irrigation alternating between the right and left lateral trocars. The median raphe of the strap muscles was opened to expose the isthmus, thyroid, and trachea (Fig. 5B). The strap muscles as well as the sternothyroid muscle were dissected off the thyroid lobe of interest. A 2/0 silk was passed transcutaneously into the working space, passed around the strap muscles with the laparoscopic instruments, and back out through the skin, where it was used as an external hanging suture to

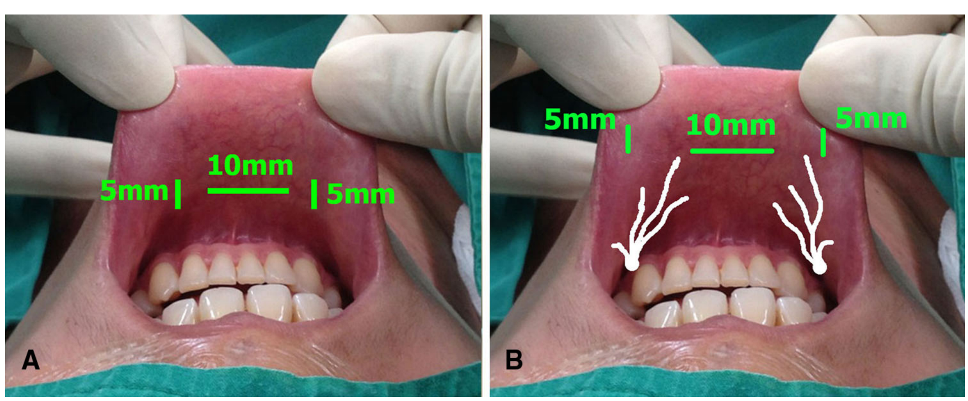

Fig. 2 Three oral vestibular incisions: **A** previous incision [15]; **B** new refined incision to prevent mental nerve injury

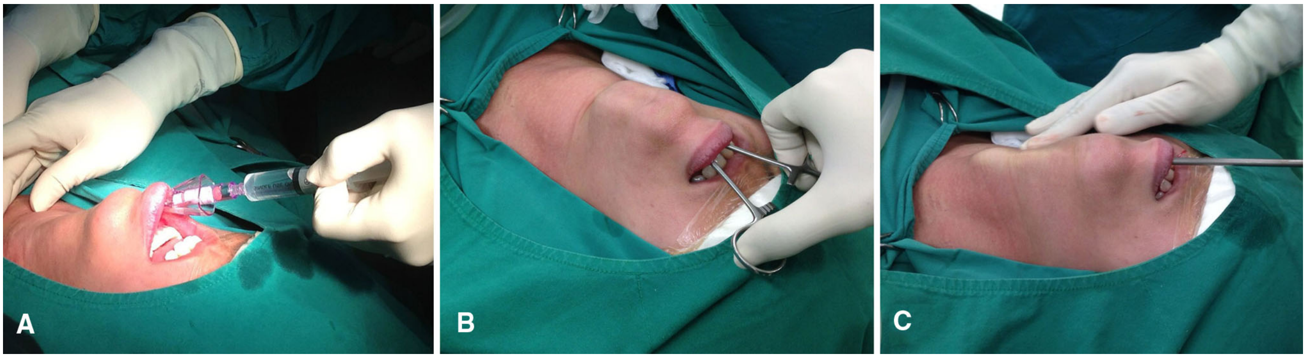

Fig. 3 Working space creation: **A** hydrodissection using a Veress needle; **B** using a Kelly clamp to overpass the chin; **C** flap creation using a rod-shaped dissector

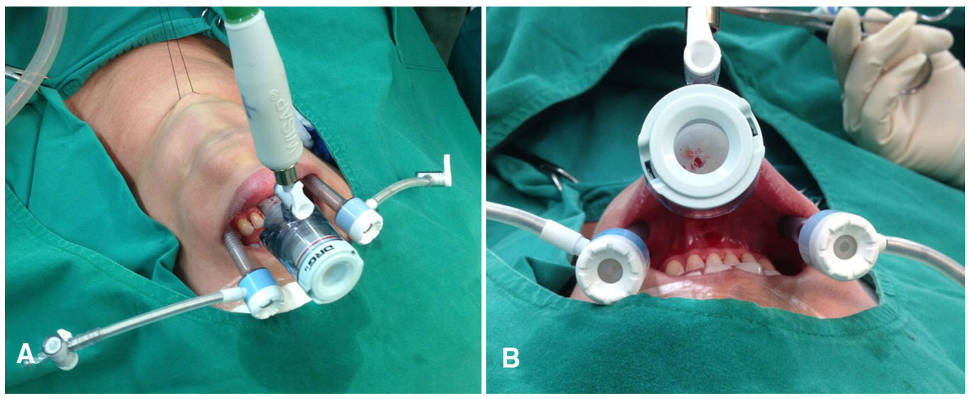

Fig. 4 Three oral vestibule incisions

assist in elevating the strap muscles laterally (Fig. 5C). At times, the sternothyroid muscle was divided at the insertion on the cricoid in order to facilitate the view of the superior pole.

Thyroid dissection

Dissection of the thyroid lobe began with the pyramidal lobe and continued inferiorly with the division of the isthmus close to the contralateral thyroid lobe using an ultrasonic device (Fig. 5D). Subsequently, an avascular plane between the superior pole and thyroid cartilage, which is called Joll's space, was opened and elevated to expose the superior thyroid vessels. Sometimes, the external branch of the superior thyroid nerve (EBSL) can be identified in this space, inserting into the cricothyroid muscle (Fig. 5E). The superior thyroid vessels were then cut with the ultrasonic device close to the thyroid to preserve the EBSL and the upper parathyroid gland (Fig. 5F).

Recurrent laryngeal nerve identification

After superior pole dissection, the thyroid lobe was retracted to the opposite side using a grasper. This medial-rotation maneuver can help to expose the tracheoesophageal groove. The recurrent laryngeal nerve (RLN) is identified at the insertion and dissected parallel to the trachea and downwards perpendicular to the inferior thyroid artery, near the lower parathyroid gland (Fig. 5G). Then, the thyroid gland was cut close to the thyroid capsule in order to preserve the RLN and lower parathyroid gland. The remaining ligament of Berry was then divided. This procedure should be performed carefully by keeping the active blade of the ultrasonic device as far away from the RLN as possible.

Specimen extraction

After the lobectomy was completed, an endobag with a purse string suture and long tail was inserted into a 10 mm trocar with the camera removed. The bag was advanced into the working space, unrolled, and positioned in such a way that the free thyroid lobe could be placed into the endobag and the suture pulled to close the purse-string. Subsequently, the camera and 10 mm trocar were removed as were the lateral laparoscopic instruments. The bag was then retracted through the central incision and delivered into the vestibule. For a tumor <4 cm, the specimen could be extracted en bloc through this incision using a "push and pull technique" (Fig. 5H). The sponge forceps were first inserted into the 10 mm-incision, with the thyroid lobe grasped inside the bag. Subsequently, the thyroid specimen

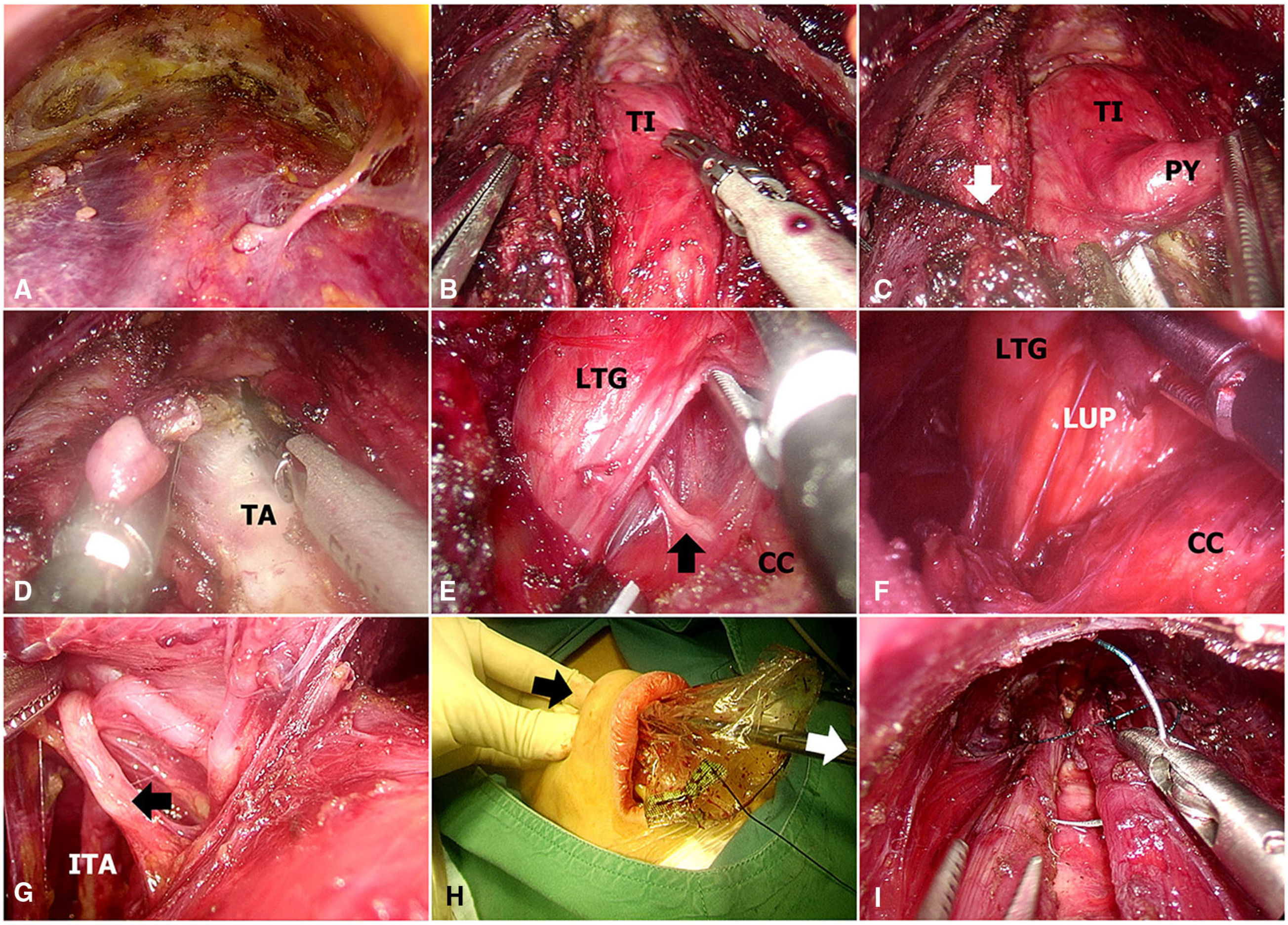

Fig. 5 Surgical technique: **A** boundary of the working space; **B** midline dissection to expose the thyroid and trachea; **C** external hanging suture (*white arrow*); **D** isthmectomy; **E** Joll's space and superior poll dissection, external branch of the superior laryngeal nerve (*black arrow*); **F** upper parathyroid gland; **G** medial rotation to expose the RLN (*black arrow*); **H** specimen extraction using an endobag with a "push and pull technique", *arrow* direction of specimen extraction; **I** strap muscle closure; *TI* thyroid isthmus, *PY* pyramidal lobe, *TA* trachea, *LTG* left thyroid gland, *CC* cricoid cartilage, *LUP* left-upper parathyroid gland, *ITA* inferior thyroid artery

was pulled out with the sponge forceps using the surgeon's right hand, while the bottom of the thyroid specimen was pushed from the outside using the surgeon's left hand. With this maneuver the thyroid lobe could be extracted as a single intact specimen. For larger tumors, the thyroid capsule had to be cut 2–3 times using endo-scissors in the endobag under endoscopic view before removing the smaller specimens, while taking care not to disrupt the nodule. Cutting and extraction should be performed entirely within the endobag to avoid seeding of the working space. If total thyroidectomy is necessary, the procedure is repeated on the contralateral side. For papillary microcarcinoma patients, central neck lymph node level VI dissection was routinely performed in addition to the previously mentioned steps.

Hemostasis was then confirmed. In the case of lobectomy, no surgical drain was needed. In the case of total thyroidectomy, a surgical drain was placed by making a separate 5 mm-incision above the clavicle and inserting a 5 mm trocar for a No. 10 Redivac drain. Afterward, the strap muscles were re-approximated using 3/0 Polyglactin sutures (Fig. 5I). The oral cavity incisions were closed using 4/0 Polyglactin sutures (Fig. 6).

Postoperative management

A gauze pressure dressing was placed around the chin for 24 h. Sipping water was allowed immediately after surgery. Patients received a liquid diet on the day of surgery (day 0) and a soft diet 1-day postoperatively. Patients were allowed to rinse their mouths with mouthwash and brush their teeth at 1 week postoperatively. Intravenous antibiotics were given for 48 h and switched to oral antibiotics until 7 days postoperatively. If a surgical drain was deemed necessary, it was removed on day 2 postoperatively. Average Visual Analog Pain Scale (VAS) were assessed

Fig. 6 Oral vestibule incisions after suturing

daily until day 3 postoperatively. For those patients discharged home before 3 days, post-operative VAS scores were obtained by phone call. Patients were admitted for 2–3 days, with follow-up at 1-week, 1-month, 3-month, 6 months and 1 year clinical visits after surgery (Fig. 7). The patients were assessed for vocal cord function by flexible or rigid laryngoscope at an outpatient clinic. Hypoparathyroidism was defined with the level of PTH lower than the lower limit (11 pg/mL).

Results

This series of patients reported herein do not include the initial series of 60 patients previously published [15]. From February 2015 to December 2015, 200 patients comprising 8 males (4%) and 192 females (96%) consecutively received TOETVA. No conversion to conventional open surgery was necessary. The mean age of patients was 40.76 ± 12.06 years (16–81 years). From a total of 200 patients, 110 cases were single thyroid nodule/cyst (55%), 66 cases were multinodular goiters (33%), and 13 cases were Graves' disease (6.5%), with the remaining 11 cases being papillary microcarcinoma (5.5%). Hemithyroidectomy was performed in 111 cases (55.5%), while total thyroidectomy or Hartley–Dunhill procedure was performed in 89 cases (44.5%). The average thyroid nodule size was 4.1 ± 1.78 cm (1–10 cm). Median operation time was 97 ± 40.5 min (45–300 min), which was 85 ± 22.42 min (45–177 min) for hemithyroidectomy and 130 ± 40.38 min (45–300 min) for bilateral thyroidectomy. Median blood loss was 30 ± 46.25 mL (6–300 mL), which was 20 ± 38.33 min (6–200 min) for hemithyroidectomy and 50 ± 52.3 min (7–300 min) for bilateral thyroidectomy. The average VAS measurements were 2.41 ± 2.04 (0–7), 1.17 ± 1.4 (0–5), and 0.47 ± 0.83 (0–3) on the first, second, and third post-operative day, respectively. The average hospital stay was 3.2 ± 0.53 days (2–5 days). The average length of follow-up is 8.5 months (Table 2).

Temporary hoarseness occurred in 8 patients (2.67%). RLN injury was confirmed by vocal cord motion impairment found on laryngoscopy. Right RLN injury and left RLN injury occurred in 6 and 2 patients, respectively. Office laryngoscopy was performed at all clinical visits until 6 months after surgery. Return of normal vocal cord motion took 2.85 months, on average. No permanent RLN injury was found.

Temporary hypoparathyroidism was observed in 35 patients (17.5%). No permanent hypoparathyroidism occurred. Lower lip numbness, likely secondary to mental nerve injury, was found in 3 patients (1.5%) and resolved in 3 months. Seroma formation was found in 10 patients (5%) and treated with simple aspiration. Post-operative hematoma was found in 1 patient and treated with open surgery. Subcutaneous emphysema was found in 7 patients (3.5%) and treated by conservative treatment, with resolution within 24 h. No other types of infection or complications were encountered (Table 3).

Discussion

In this study, the largest single-institution case series of TOETVA to date has been presented, demonstrating the safety and feasibility of this approach. This technique evolved out of a mutual desire by patients and surgeons alike for a scarless, minimally-invasive approach with the goal of optimizing cosmesis and quality of life after surgery [16–18] while avoiding many of the limitations of other remote-access approaches to the central neck.

Requisite to adopting any new surgical technique is scrutiny and analysis to confirm that the procedure is feasible and safe with the ultimate comparison to the gold standard of open transcervical thyroidectomy. To that end, an international group of surgeons formed the TONS Study Group to ensure the responsible adoption and evolution of this technique while ensuring patient safety. Experienced surgeons that have experimented with or performed transoral thyroidectomy at their respective institutions, whether endoscopic or robotic, are included in this manuscript [19–22].

Transoral thyroidectomy approaches currently include both a sublingual [10–12] and an oral vestibular [13–15] approach. The sublingual approach was first reported in 2007 by Witzel et al. [8], who successfully performed transoral endoscopic thyroidectomy on 10 living pigs using a single port cervicoscope through the midline of the sublingual area. Benhijeb et al. [9] subsequently reported

Fig. 7 Postoperative follow-up after: **A** 1 week; **B** 1 month

the performance of this technique on 5 human cadavers in 2009. Later, Karakas et al. [10] reported their experience on 10 living pigs and 10 human cadavers and performed transoral endoscopic parathyroidectomy on 2 patients by placing a 20 mm incision at the lateral floor of the mouth and using a cervicoscope. However, one patient experienced hypoglossal nerve injury. Wilhem et al. [11] also reported the use of a 1 cm sublingual port combined with 5 mm vestibular ports to perform thyroidectomies on 8 patients. Although there remains interest in the sublingual approach [23], enthusiasm has been dampened by high complication rates secondary to violation of the floor of the mouth, which have made this technique less popular and widely criticized [24].

The oral vestibular approach involves making all incisions anterior to the mandible without violating the floor of the mouth or ventral tongue. It was first described by Richmon et al. in a cadaveric study exploring a transoral robotic thyroidectomy approach [19]. In 2013, Nakajo et al. [13] reported their experience with Transoral Video-Assisted Neck Surgery (TOVANS) on 8 patients using a 2.5 cm single incision in the oral vestibule with a gasless technique. One patient developed RLN palsy and all 8 patients developed mental nerve injury. Later, Wang et al. [14] reported a completely oral vestibular approach with 3 ports on 12 patients. Yang et al. [25] also reported the vestibular procedure on 40 patients with minimal complications. Recently, the first author published a report on his TOETVA experiences at Police General Hospital in Bangkok on the largest series of 60 patients with excellent results [15]. This report further establishes the transoral vestibular approach as the preferred transoral technique to access the neck. This is due in part to the ease of the approach, the excellent view of the surgical field afforded when the camera passes anterior to the mandible, and the avoidance of a sublingual incision with its inherent complications. Moreover, the rapidly accruing world experience with this technique has demonstrated a very favorable safety and feasibility profile. The authors' report bolsters this experience with the largest case series heretofore reported and reviewed by the international TONS Study Group.

Table 2 Demographic data and operative details

Characteristics and details	Value
Age (mean, years)	40.76 ± 12.06 (16–81)
Sex ($n = 200$)	
Male	8 (4%)
Female	192 (96%)
Thyroid disease ($n = 200$)	
Single thyroid nodule/cyst	110 (55%)
Multinodular goiter	66 (33%)
Graves' disease/toxic adenoma	13 (6.5%)
Papillary microcarcinoma	11 (5.5%)
TOETVA procedure ($n = 200$)	
Hemithyroidectomy	111 (55.5%)
Bilateral thyroidectomy	89 (44.5%)
Operative time (median, minutes)	97 ± 40.50 (45–300)
Hemithyroidectomy	85 ± 22.42 (45–177)
Bilateral thyroidectomy	130 ± 40.38 (45–300)
Blood loss (median, mL)	30 ± 46.25 (6–300)
Hemithyroidectomy	20 ± 38.33 (6–200)
Bilateral thyroidectomy	50 ± 52.3 (7–300)
Hospital stay after surgery (mean, days)	3.2 ± 0.53 (2–5)
Tumor size (mean, cm)	4.1 ± 1.78 (1–10)
Conversion to open surgery	1 (0.5%)
Average length of follow-up (months)	8.5
VAS pain score ($n = 200$, mean)	
Day 1	2.41 ± 2.04 (0–7)
Day 2	1.17 ± 1.4 (0–5)
Day 3	0.47 ± 0.83 (0–3)

Table 3 Postoperative complications

Complications	Number ($n = 200$) (rate)
Hypoparathyroidism	
Temporary	35 (17.5%)
Permanent	0
Recurrent laryngeal nerve (RLN) injury	
Temporary	8 (4%)
Right RLN injury	6
Left RLN injury	2
Permanent	0
Mental nerve injury	3 (1.5%)
Hematoma	1 (0.5%)
Infection	0
Subcutaneous emphysema	7 (3.5%)
Pneumomediastinum	0
Seroma	10 (5%)
Tracheal injury	0
Esophageal injury	0

Generally, the indications for endoscopic thyroidectomy include benign disease, papillary microcarcinoma, and thyroid tumor size <6 cm [4–6]. With the TOETVA technique utilized by the authors, thyroid tumors as large as 10 cm have been removed (personal experience). However, tumors with sizes no larger than 6–8 cm should be considered as the upper limit, especially for those with limited experience. In order to remove the thyroid specimen through the central vestibular incision, care must be taken not to rupture the endobag and avoid contamination or seeding of the tumor to the working space. The central incision has to be extended to 3 cm and the "push and pull technique" has been used to extract the specimen in order to retain an intact capsule and favorable pathological result (Fig. 5H). For benign thyroid disease, such as well-controlled Graves' disease and goiters <8 cm, the thyroid lobe must be cut away from the nodule inside the endobag in order to extract it from the central incision. For thyroid cancer, the nodule should be limited to <2 cm for TOETVA. The authors' nascent experience with this technique included a small number of patients with papillary microcarcinoma who would not require additional treatment as per the 2015 American Thyroid Association guidelines [26]. The authors caution against the inclusion of malignant disease at this point, but are very encouraged by the results of this study. If completion thyroidectomy is advised in the patients with neoplasm ultimately found to be thyroid carcinoma, a repeat-TOETVA for the contralateral thyroid gland can be performed within 2 weeks or after 6 months. On the other hand, transaxillary endoscopic thyroidectomy is another option for completion thyroidectomy of the contralateral thyroid lobe. A major advantage of TOETVA is the midline approach to the central neck, which allows access for a total thyroidectomy and central neck dissection. Such an approach is unparalleled compared to other remote-access approaches.

Paramount to any thyroid surgery is the identification and preservation of the RLN. Generally, percentages of temporary and permanent RLN injury in open thyroidectomy procedure range from 2.11 to 11.8% and 0.2 to 5.9% [27–29], respectively. In this study, temporary and permanent RLN injury accounted for 2.67 and 0%, respectively, which is a similar rate compared to conventional open surgery. The TONS Study Group continues to protocolize the meticulous assessment of RLN function, which will be addressed in future studies.

Identification and preservation of the parathyroid glands is also critical for any thyroid surgery. TOETVA allows for easy identification of the glands, which is facilitated by the magnified, high-definition laparoscopic view. After cutting the super thyroid vessels and elevating the superior thyroid lobe to the opposite side, the superior parathyroid gland was often visualized (Fig. 4F). This, in combination with the RLN, was helpful in identifying the inferior parathyroid gland. The transient and permanent hypoparathyroidism rates were 17.5 and 0%, respectively, comparable to those of standard open thyroidectomy (0–11% and 0–5.7%, respectively [27, 28, 30, 31]).

The transoral approach to the neck must be considered clean-contaminated surgery and carries an inherently greater risk of infection than clean transcervical thyroidectomy [32]. Nonetheless, the authors did not observe any post-operative infections in this large case series, which is likely due to the meticulous oral preparation and peri-operative administration of antibiotics.

Seroma formation is a minor complication of endoscopic thyroidectomy [33]. Patients may be at greater risk of seroma formation given the larger flap elevation necessary to create a working space. Ten patients (5%) experienced seromas, all of which were treated with simple aspiration without further sequela.

The mental nerves exit from the mental foramen between the first and second premolars. The nerves provide sensory innervation to the chin and lower lip. Previous reports of the transoral approach document a high complication rate for mental nerve injury [11, 13, 14]. In contrast to previous studies, the authors documented a very low rate (1.5%) of transient nerve injury, which completely recovered within 2–4 months. However, the 5 mm incisions in the first 100 cases were close to the center incisions, as described in a previous study [15]. Mental nerve injury was found in 3 patients. Therefore, the authors refined both 5 mm incisions to make them as lateral as possible, lateral to the canine teeth, and very close to the lower lip (Fig. 2B). With these new incisions, there was no mental nerve injury in the cases that followed. This was likely due to modification of the location for the lateral port incisions closer to the free lip edge, which allowed for greater mobility of the lip during the procedure while imparting less tension on the mental nerve where it exits the foramen.

We understand that the average length of stay in this study is longer than that typically experienced in the West, especially the United States. There are many factors involved in LOS beyond that of just the medical condition of the patient, including reimbursement models and social and cultural expectations. In Asian countries, it is common for patients to remain in the hospital for the duration of recuperation from surgery rather than transition post-operative care to home. We did not experience any difference in LOS between those patients receiving TOETVA versus conventional open thyroidectomy in our hospital. Furthermore, there has been experience with safe overnight hospitalization after TOETVA by other authors in this manuscript and in the literature [34]. While the indications for thyroid surgery continue to evolve and the authors acknowledge that there are patients in this series who would be candidates for observation under new guidelines [26], the purpose of this report was to further characterize the transoral thyroidectomy approach. There has been a great deal of enthusiasm for the TONS approach, with many surgeons around the world poised to introduce this technique at their hospitals. The TONS technique is challenging, even for the most experienced surgeon, with a steep learning curve. This procedure should not be undertaken by an inexperienced thyroid surgeon. Furthermore, this approach involves several skills in which most thyroid surgeons may not be adept, including advanced laparoscopy skills and working within a narrow working space in the neck. Both transoral robotic and endoscopic thyroidectomy approaches are currently being utilized by members of the TONS Study Group. It cannot be over-emphasized that appropriate preparation is necessary to perform this surgery successfully. This goes beyond just the surgeon and requires that all operating room staffs are familiar with the procedure. The authors submit that this requires case observations, cadaveric dissections, and mentored initiation of one's first cases to ensure the requisite skills and familiarity with this novel procedure.

Conclusion

The authors report the largest single-institution case series of TOETVA to date with an excellent safety and feasibility profile. The advantages of this technique over other remote access approaches include its ability to afford equal access to both sides of the neck, the decreased tissue dissection required, and the excellent view of the anatomy provided, similar to an open approach. Further, it is the only approach that avoids any cutaneous scarring. The TONS Study Group will continue to evaluate this technique using both robotic and endoscopic instrumentation while measuring functional, cosmetic, and quality-of-life outcomes.

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Compliance with ethical standards

Disclosures Dr. Angkoon Anuwong, Dr. Thanyawat Sasanakietkul, Dr. Pornpeera Jitpratoom, Dr. Khwannara Kantha, Dr. Hoon Yub Kim, Dr. Gianlorenzo Dionigi and Dr. Jeremy Richmon have no conflicts of interest or financial ties to disclose related to the work herein.

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