



## Strategies for superior thyroid pole dissection in transoral thyroidectomy: a video operative guide

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### Abstract

**Background** The dissection of the superior thyroid gland pole is challenging when using the in TransOral Endoscopic Thyroidectomy Vestibular Approach (TOETVA) due to (a) the cranio-caudal approach, (b) cranial-caudal view, and (c) the restriction of maneuverability inside the narrow neck air pocket.

**Methods** In this paper and operative video guide, a series of TOETVA's tips and tricks are presented with an emphasis on the strategies for a safe approach to the superior thyroid gland pole structures.

**Results** Management of the upper thyroid pole structures includes: (a) use of a 5 mm/30°-45° endoscope; (b) retraction ports up to the limit of the lower jaw edge; (c) lateral retraction of 1/3 of the cranial strap muscles; (d) isthmectomy; (e) cutting the sternothyroid muscle cranially for 1 cm; (f) retraction of the thyroid upwards and laterally; (g) monitoring the external branch of the superior laryngeal nerve, and (h) sealing individual vessel branches.

**Conclusion** Access to the superior thyroid pole space through the TOETVA approach presents some challenges, particularly when accessing thyroid vessels or nodules located or displaced more cranially. Strategies that enhance a critical view of the superior thyroid gland structures can protect them from damage and have the potential to improve the safety of the TOETVA and decrease potential conversion rates.

**Keywords** Transoral endoscopic thyroidectomy · Intraoperative neuromonitoring · Vestibular approach · Superior laryngeal nerve

The TransOral Endoscopic Thyroidectomy Vestibular Approach (TOETVA) has been introduced as an alternative for endoscopic endocrine neck procedures [1]. TOETVA creates no visible incision in the skin, neck and/or

other areas of the body compared to other approaches [2, 3]. There is some evidence that TOETVA facilitates the route to the anterior neck (in comparison to axillary, breast, or retro-auricular approaches) leads to reduced operative time [4, 5]. Another attraction is that bilateral procedures can be performed safely through TOETVA [6, 7]. Additional surgical anatomical knowledge for TOETVA expands understanding of spatial orientations of the neck structures [8]. TOETVA is performed with a cranial to caudal, top-down

Hui Sun and Antonella Pino have equal contributions.

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36 view and dissection of the thyroid and parathyroid glands,  
 37 recurrent laryngeal nerve (RLN) and external branch of the  
 38 superior laryngeal nerve (EBSLN) [9, 10]. The aim of this  
 39 paper and operative video guide is to describe the different  
 40 stages of TOETVA, showing specifically the management  
 41 of the superior thyroid gland pole. This crucial step of the  
 42 intervention requires optimal visual control for the surgeon,  
 43 but due to the cranial to caudal, top-down view, and restric-  
 44 tion of maneuverability inside the neck air pocket, does not  
 45 allow ideal visual access to the superior thyroid pole. This  
 46 detracts from the safety of the approach (Fig. 1).

## 47 Materials and methods

48 The approval of an IRB/IEC is not necessary for this work.

### 49 Equipment

50 TOETVA is performed under general anesthesia with  
 51 naso- or oro-tracheal intubation using an electromyo-  
 52 graphic (EMG) tube (Trivantage EMG tube, Medtronic,

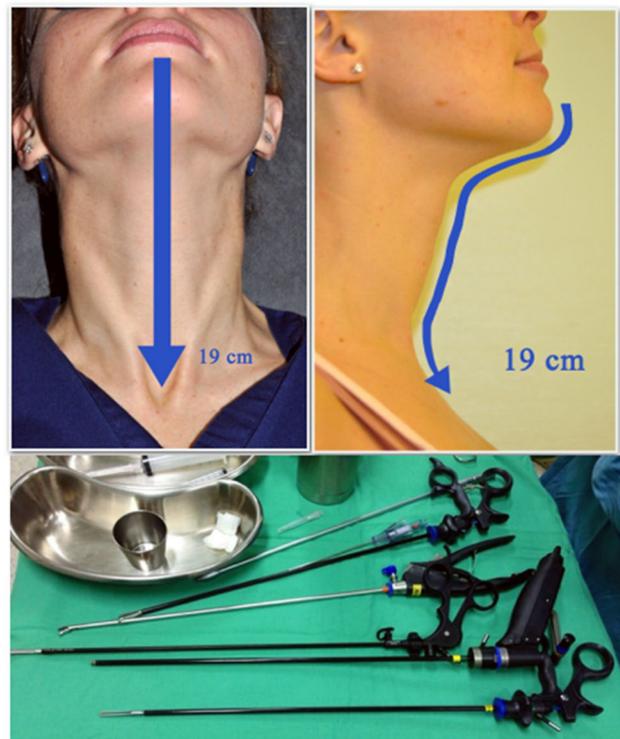
Jacksonville, Florida, USA). This allows for intraoperative  
 53 neural monitoring (IONM). The operative room setting  
 54 includes the surgeon, standing at a position near the patient's  
 55 head; first assistant, sitting on the left; and a second assistant  
 56 and nurse on the right. HD and IONM monitors are at the  
 57 foot of the patient. Surgical instruments include: standard  
 58 neck tray, Veress needle for hydro-dissection, straight vas-  
 59 A01 cular space probes that can create tunnels, a Kelly clamp,  
 60 one 10 mm trocar, two 5 mm trocars, a 30° 5 mm scope,  
 61 conventional endoscopic instruments such as a Maryland  
 62 dissector, a tissue grasper, a needle holder, vascular clips, an  
 63 energy-based device (EBD), suction and an endobag. Endo-  
 64 scopic instruments should have a length greater than 20 cm  
 65 to safely access all anatomical structures of the neck (Fig. 2).  
 66 The authors have used different EBDs (such as Thunderbit,  
 67 Harmonic and Ligasure Maryland) according to their avail-  
 68 ability in the operating room and the surgeon's preferences.  
 69

### Endoscope

70 We suggest using the 5 mm endoscope because of its ubiq-  
 71 uitous use in all 3 ports. In the case of a difficult exposure of  
 72

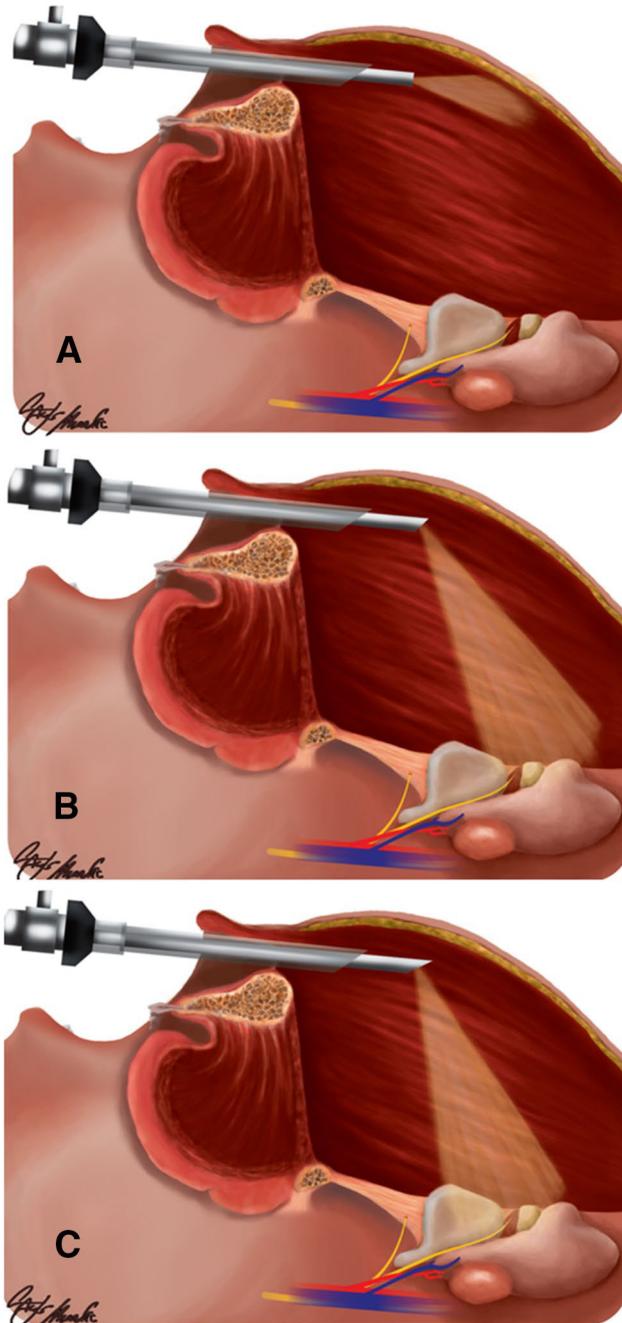


**Fig. 1** TOETVA is performed with a cranial to caudal, top-down view and dissection of the thyroid and parathyroid glands, RLN and EBSLNs. Visualization of the superior thyroid pole (the EBSLN, vessels and superior parathyroid glands) is limited because (i) the sternothyroid muscle covers the anatomical structures; (ii) endoscopic vision is limited by interference between the mandible and the ports; (iii) on the left side, there is interference of endoscopic vision by the laryngeal prominence and by crossover of instruments



**Fig. 2** Endoscopic instrument length. Proper selection of endoscopic equipment includes material length. We measured the distance between the lower lip and the sternum in 50 consecutive female patients, aged between 20 and 40 years old. The average estimated length was  $19 \pm 5$  cm. Considering the coexisting presence of the port and instrument handle, we recommend using endoscopic instruments longer than 30 cm for safer dissection of the upper pole structures

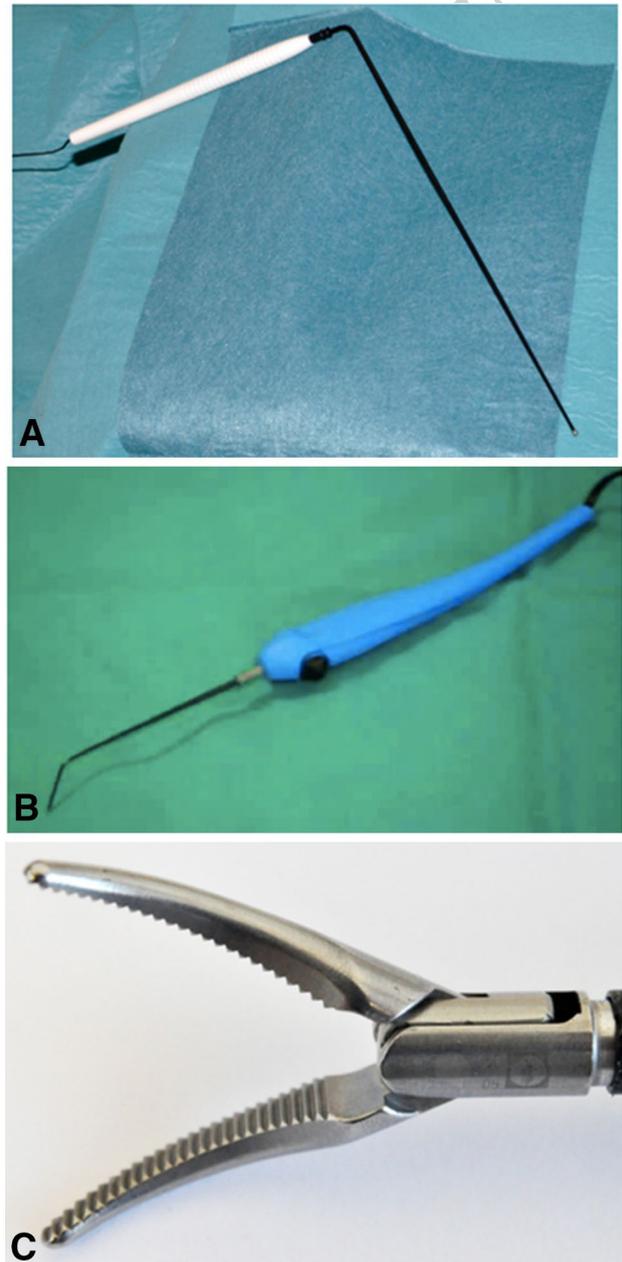
73 the superior thyroid vessels, the superior laryngeal nerves or  
 74 bleeding, the use of the 5 mm camera offers more modalities  
 75 for display from all 3 ports. The 30° or 45° cameras are the  
 76 optimal ones for a correct view (Fig. 3). The application of  
 77 flexible endoscopes will favor the procedure.



**Fig. 3** Perspectives for 0° (A), 30° (B) and 45° (C) endoscope used in TOETVA. The 30° and 45° cameras are the optimal ones for a correct view of the superior thyroid pole. Furthermore, to enhance endoscopic visualization we suggest that the ports be retracted up to the limit with the inferior edge of the jaw

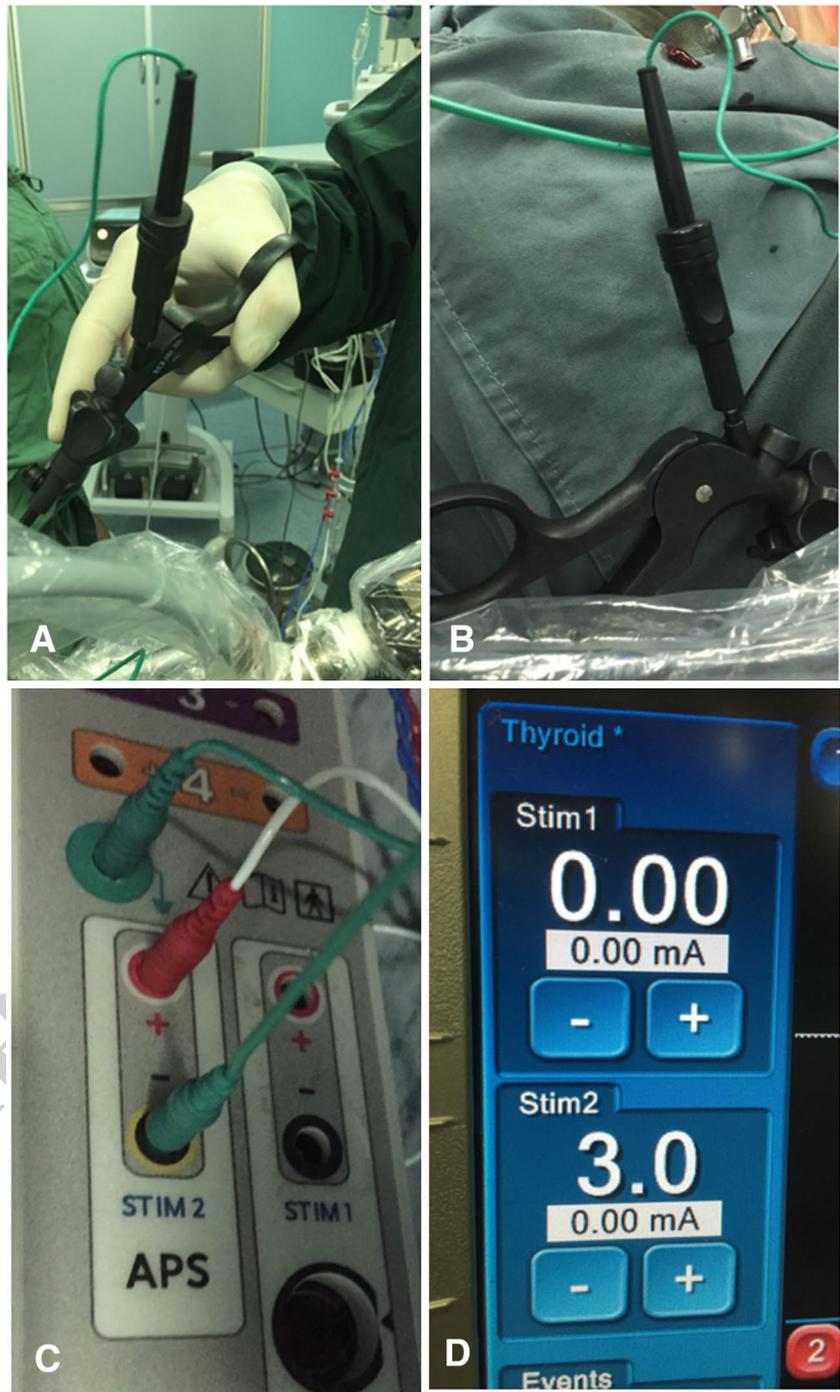
## Neural monitoring

EBSLN stimulation is achieved by either (a) a percutaneously placed monopolar stimulator probe, (b) adapted Maryland dissector, or (c) a long stimulating probe [10–12] (Figs. 4, 5). The use of one or other mode of stimulation is dictated by availability in the operating room. IONM is a useful adjunct for EBSLN identification and mapping



**Fig. 4** Different modes for EBSLN and RLN stimulation. EBSLN stimulation and monitoring is achieved by (A) a long stimulating probe, (B) a percutaneously placed monopolar stimulator probe, or (C) an adapted Maryland endoscopic dissector–stimulator

**Fig. 5** Details of the adapted IONM Maryland endoscopic dissector–stimulator. An endoscopic Maryland dissecting instrument (code DJ-FL05, Kangji Medical Equipment co, Ltd. China), 330 mm in length and 5 mm in diameter is used (A). The clinical engineer adapted the instrument to the IONM connective box by a cable. One end of the cable is connected to the connective box as to the traditional intermittent nerve monitoring probe (A–C). The other end is connected to the dissecting instrument. Continuous stimulation is necessary to use the instrument as a dissector and stimulator at the same time (D). The same mode of stimulation was applied for both the RLNs and EBSLNs



85 (Supplementary Video) [10–12]. The same mode of stimu-  
 86 lation was applied for both the RLNs and EBSLNs. The  
 87 event threshold was set with a reduced response threshold  
 88 to identify small responses at 50  $\mu$ V [12]. Nerve moni-  
 89 toring was performed according to the standards of the  
 90 equipment set up, induction and maintenance of anesthe-  
 91 sia, correct tube positioning verification tests, and EMG  
 92 definitions [12].

### Patient position

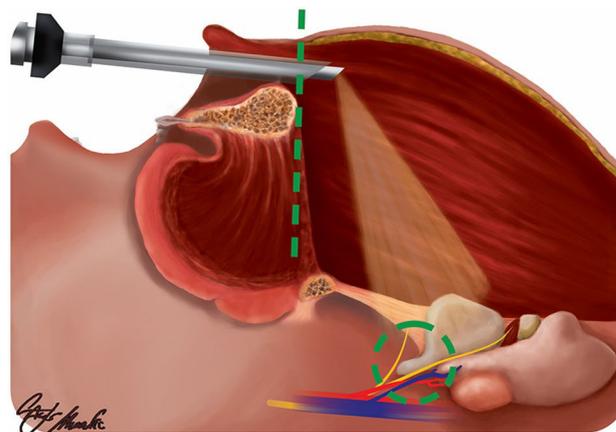
The patient is in a supine position with slight neck exten-  
 sion and in a 15°–30° Trendelenburg bed position. This  
 position allows better direct access to organs in the neck  
 (Fig. 6).



**Fig. 6** **A** Non Trendelenburg bed position: ports, endoscope and instrument directions are toward the sternum, far from the neck. **B** To better access the neck organs, the patient lies in a supine position with slight neck extension and in the 15–30° Trendelenburg position. The slightly extended neck also favors the creation and maintenance of the air pocket and decreases postoperative cervical back pain

## 98 Exposure

99 To safely perform superior thyroid pole dissection, the  
100 vascular anatomy must be exposed, and adjacent struc-  
101 tures, especially the EBSLN, identified. The working  
102 space is created bluntly, under direct endoscopic visu-  
103 alization, beneath the subplatysmal layer via the oral ves-  
104 tibule, and through the pre-mandibular space by using a  
105 straight vascular tunneling probe. Low pressure CO<sub>2</sub> gas



**Fig. 7** Suggested position of the ports during upper pole dissection (dotted green circle). Ports are retracted up to the limit of the inferior edge of the jaw (green dotted line) for better endoscopic visualization

insufflation (6 mmHg), energy-based devices (EBD) are 106  
used with external mechanical lifting by sutures [1]. The 107  
superior border is the larynx and the inferior border is 108  
the suprasternal notch. The lateral borders are the ante- 109  
rior and medial borders of both sternocleidomastoid mus- 110  
cles [1]. Laterally, both for a lobectomy and for bilateral 111  
procedures, the dissection is continued up to the medial 112  
border of the sternocleidomastoid muscle bilaterally [1]. 113  
The strap muscles are divided and retracted by cutting the 114  
midline linea alba cervicalis and the deep fascia. 115

To emphasize exposure of the superior pole thyroid struc- 116  
tures (Supplementary Video) (Table 1): 117

Use a 5 mm, 30°–45° endoscope, for ubiquitous lateral 118  
5 mm port side use. 119

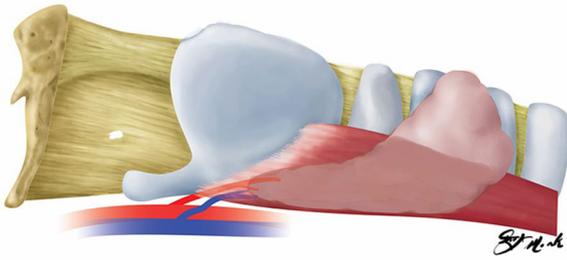
Retract ports up to the limit of the lower edge of the jaw, 120  
for better visual inspection (Fig. 7). 121

Retract the strap muscles laterally using an external hang- 122  
ing suture or a dedicated retractor. The suture and retrac- 123  
tion are performed in the cranial 1/3 of the pre-thyroid 124  
muscle (Figs. 8, 9 and 10 and Supplementary Video). 125

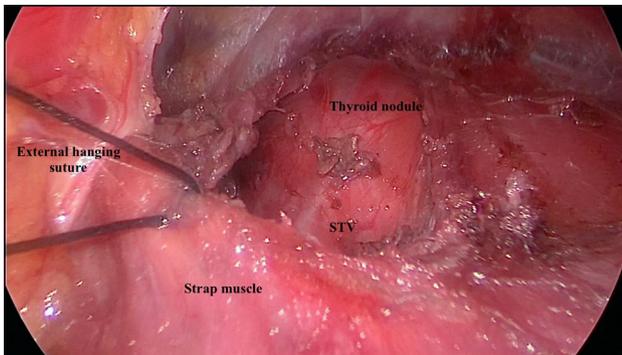
Meticulous thyroid tissue dissection. 126

Identify, dissect and separate the thyroid isthmus. Isthmus 127  
sectioning facilitates (i) gripping the thyroid gland, (ii) 128  
dissecting and exposing the sternothyroid-laryngeal tri- 129  
angle, otherwise called Jolles space, and (iii) mobilizing 130  
the upper pole. 131

Carefully cut the sternothyroid muscle (STM) cranially 132  
and superiorly for 1–1.5 cm to better expose the upper 133  
pole structures. The STM is incised until complete 134  
exposure of the superior pole of the thyroid gland is 135  
achieved. As the STM is mobilized cranially, the anter- 136  
ior branch of the superior thyroid artery will be identi- 137  
fied first. Without clear identification of these vessels 138



**Fig. 8** The upper pole of the thyroid gland does not normally extend superior to the level of the oblique line of the thyroid cartilage. Access to the superior thyroid pole space through TOETVA presents some challenges, particularly when accessing the thyroid vessels or nodules located or displaced more cranially. The sternothyroid muscle (STM) overlying the superior thyroid vessels prevents correct visualization of the upper pole and should be partially incised cranially. We believe this maneuver is mandatory in the TOETVA procedure to **A** improve the endoscopic cranio-caudal view; **B** facilitate the identification of all vascular branches; **C** facilitate EBSLN exposure; **D** facilitate vessel ligation; **E** better visualize the upper parathyroid gland and RLN at its entry point; and **F** in the case of intraoperative bleeding from the upper thyroid vessel branches, facilitate management of hemostasis. There are two modes of application for lateral muscle retraction: **A** with external stitches or **B** with a dedicated retractor



**Fig. 9** Strap muscles are retracted laterally using an external hanging suture. The suture and retraction are applied to the cranial 1/3 of the strap muscles anterior to the thyroid gland

139 EBSLN injury can occur. It also can lead to incomplete  
140 vessel sealing, which will further complicate the TOE-  
141 TVA procedure.

142 Retract the thyroid gland upwards and laterally to (i) pro-  
143 tect the EBSLN and the cricothyroid muscle (CTM), and  
144 (ii) expose the vessels more clearly. Further open Jolles  
145 space keeping the thyroid vessels lateral and the larynx  
146 medial to further expose the EBSLN. Be aware that the  
147 EBSLN lie just medial to, or superiorly or inferiorly to  
148 the arteries (Fig. 11).

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## Results

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### EBSLN identification and monitoring

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The supplementary video shows how to dissect a type 2A  
EBSLN from the superior thyroid vessels. Invariably, the  
EBSLN crosses the superior thyroid pole at the bifurcation  
of the vessels (Fig. 11). At this location, the EBSLN will  
be identified attached to the superior thyroid pole tissue. Accord-  
ing to IONM Guidelines, the surgical management of the supe-  
rior pole should include the EBSLN de visu detection and  
1 mA true positive stimulation (i.e., an EMG signal coupled  
with CTM twitch) [12]. Complementary standardized IONM  
includes: (i) pre-dissection EBSLN mapping and stimulation  
(S1); (ii) stimulation while dissecting the EBSLN. The supe-  
rior laryngeal nerve should be checked repeatedly at each step  
of TOETVA according to the needs of the surgeon; (iii) final  
verification of EBSLN integrity (S2) [12–15]. IONM mapping  
allows optimization of the level of ligation and sectioning of  
the branches of the superior thyroid artery while avoiding the  
EBSLN in the dissected tissue.

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### Superior thyroid vessel ligation

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Before reaching the upper pole of the gland and within the pre-  
tracheal fascia, the superior thyroid artery divides into 2 main  
branches, one for either surface of the gland. An EBD should  
be used carefully to ligate the artery. To avoid injury to the  
EBSLN, the branches of the superior tracheal artery are ligated  
and sectioned near the superior pole of the thyroid gland. The  
vessels are sealed individually and if necessary secured with  
clips. Upper pole vessels should not be sealed in one block;  
it is safer to seal the vessels individually with EBD (Fig. 12).

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### Challenges for superior pole of the thyroid gland dissection

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The narrow upper pole of the thyroid gland does not normally  
extend superior to the level of the oblique line of the thyroid  
cartilage (Fig. 8). Access to the superior thyroid pole space  
through TOETVA presents some challenges, particularly when  
accessing thyroid vessels or nodules located or displaced more  
cranially. It is important to emphasize that a prominent chin  
may cause a problematic exposure of the subplatysmal neck  
space (Table 2).

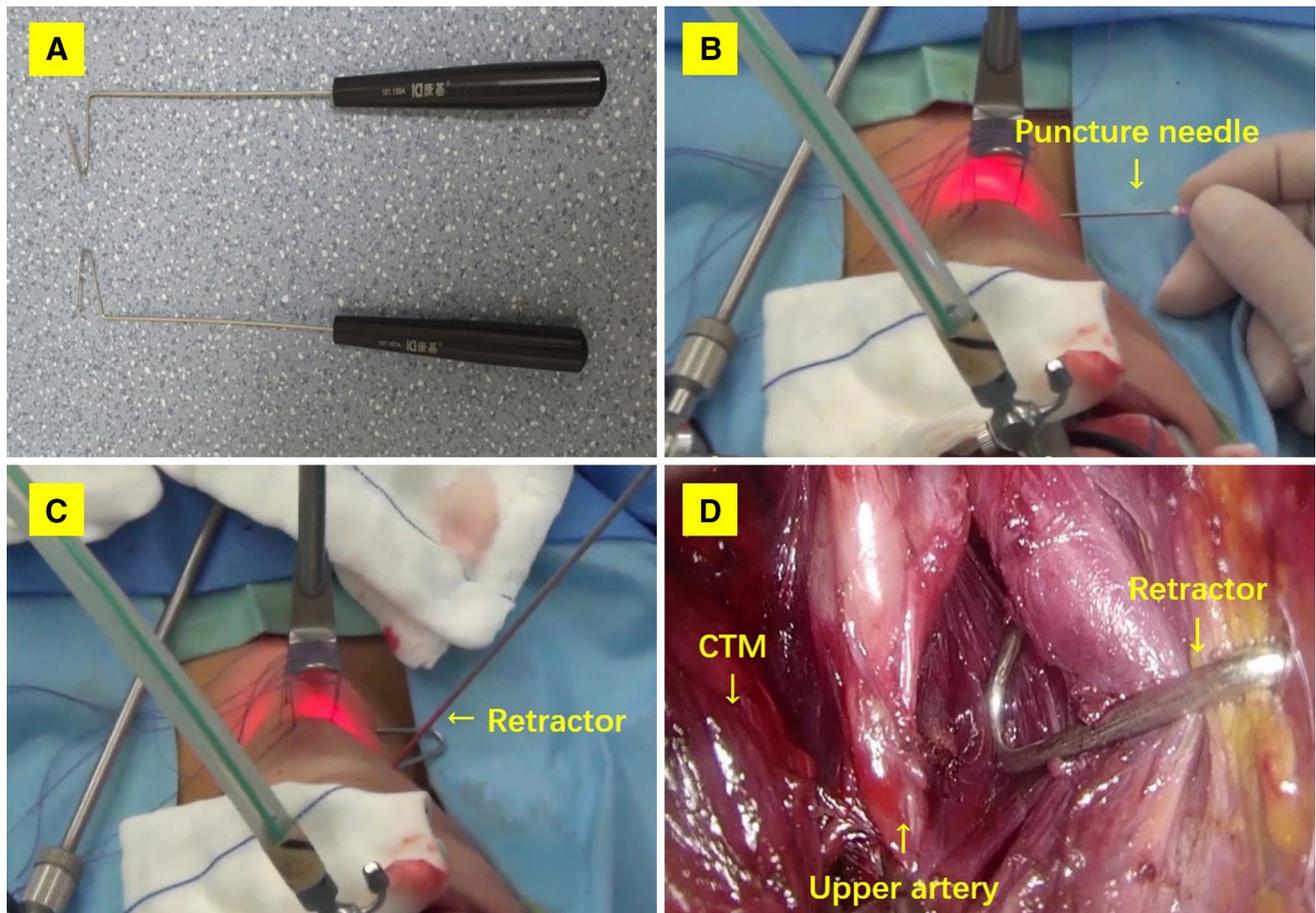
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### Management of intraoperative bleeding from the superior thyroid vessels

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Intraoperative bleeding from the superior thyroid vessels is  
the most common cause of conversion in endoscopic thy-  
roidectomy [1]. The surgeon needs not to be frightened, but

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**Fig. 10** Another option for retracting the strap muscles is a retractor placed in the surgical field (Hangzhou Kangji Medical Instrument Co., Ltd). **A** Right and left accessory nerves. **B** An orifice is created

by a needle (19G), and **C** the retractor is introduced. **D** The retractor in the surgical site. *CTM* cricothyroid muscle

194 to keep his/her concentration. The transoral surgeon should  
 195 identify the bleeding site and discontinue more thyroid dis-  
 196 section. The surgeon can try to use the EBD but should be  
 197 aware of the position and distance to the EBSLN. In case of  
 198 retraction and bleeding of the superior vessels, it is advis-  
 199 able to apply compression externally from the skin, applied  
 200 from the lower angle of the jaw inferiorly to stop the bleed-  
 201 ing. This will stretch the upper thyroid vessels inferiorly  
 202 and allow hemostasis. The STM is incised until complete  
 203 exposure of the superior pole of the thyroid gland is visual-  
 204 ized. A previous cranial incision of the STM is an important  
 205 maneuver also for the management of bleeding.

## 206 Discussion

207 Despite the well-known benefits of TOETVA to the patients,  
 208 this surgical technique creates some technical challenges for  
 209 transoral surgeons.

A large range of transoral thyroidectomy operations per-  
 formed through the vestibular approach have been reported,  
 often for surgical treatment for cancer [1, 16]. The experi-  
 ence of several surgeons passing through the learning curve  
 of the TOETVA surgery has resulted in overcoming many  
 of the early challenges [17].

We present prevention strategies, that are described in the  
 video technique guide, that are safe, technically feasible, and  
 add minimal time to the overall procedure. These techniques  
 warrant investigation in a thoughtful, prospective manner,  
 but are supported by existing data and a compelling clinical  
 rationale. TOETVA requires a close proximity of the surgi-  
 cal instruments and the endoscopic camera. This leads to  
 a loss of instrument triangulation and restricts maneuver-  
 ability inside the neck air pocket (Fig. 10). These technical  
 limitations will be increased with the introduction of newly  
 developed single port surgery [18]. Conventional endoscopic  
 instruments have limited dexterity, making some TOETVA  
 maneuvers challenging in particular for superior thyroid  
 gland pole dissection. The use of surgical ports creates a

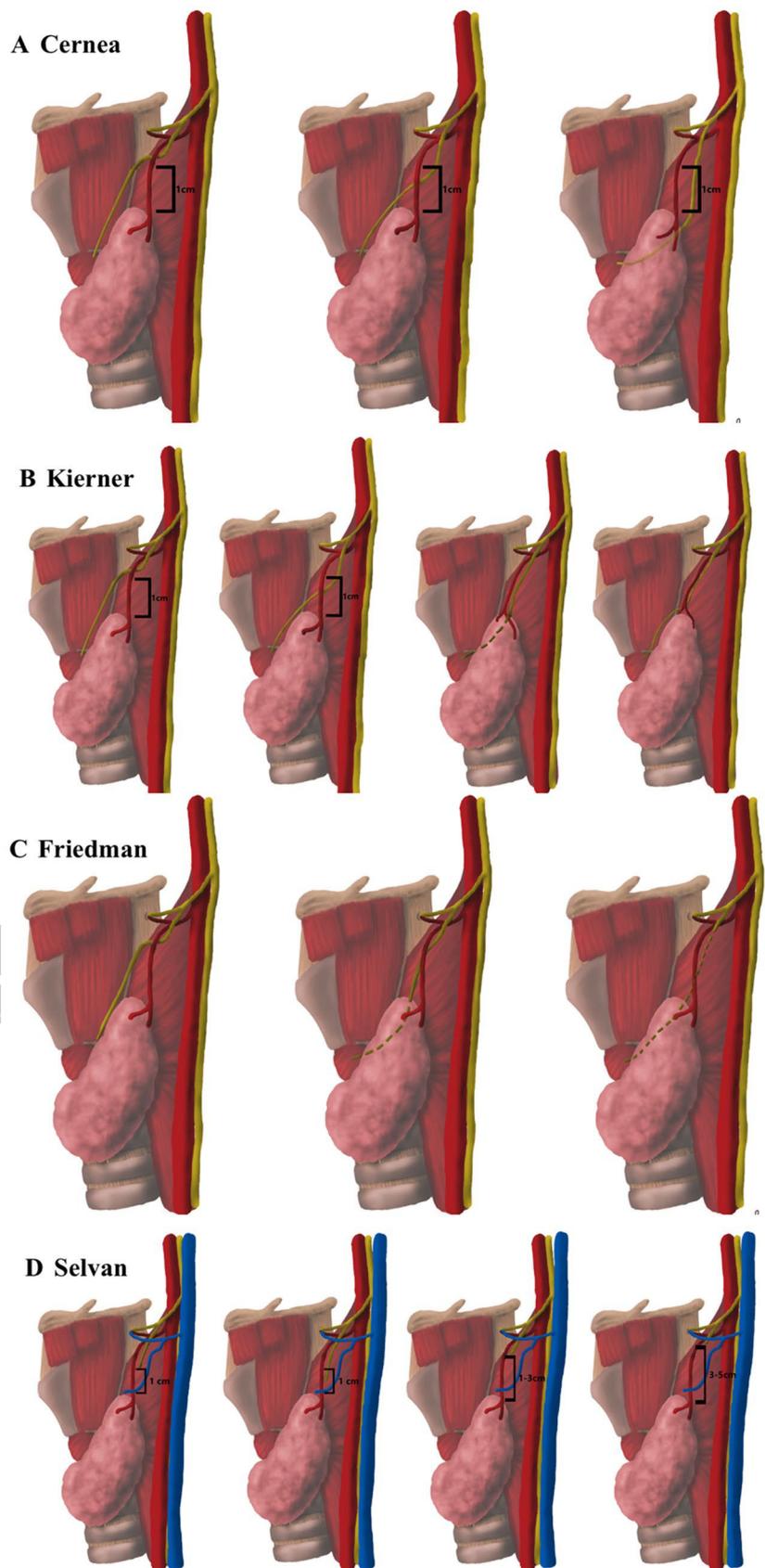
**Fig. 11** EBSLN classifications.

**A Cernea** classification: type I, the EBSLN crosses the superior thyroidal vessels at least 1 cm above a plane horizontal to the upper edge of the superior thyroid pole; type IIa, the distance is shorter than 1 cm and is not below the plane; type IIb, the EBSLN is below the plane.

**B Kierner** scheme: type I, the EBSLN crosses the superior thyroid artery (STA) more than 1 cm above the upper pole of the thyroid; type II, the EBSLN crosses the STA less than 1 cm above the upper pole of the thyroid gland; type III, the EBSLN crosses the STA under the cover of the upper pole of the thyroid gland; type IV, the EBSLN descends dorsally to the artery and crosses the branches of the STA immediately above the upper pole of the thyroid gland.

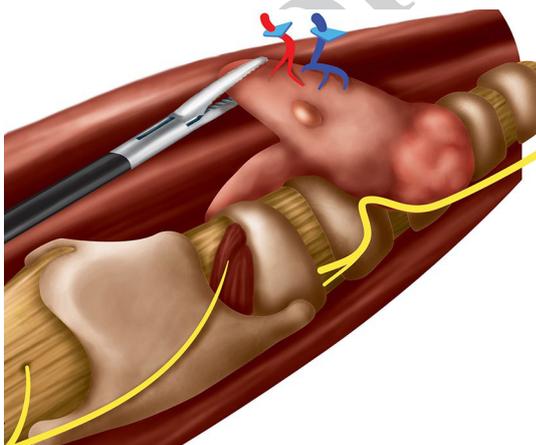
**C Friedman** classification: type 1, the nerve runs superficial to the inferior constrictor muscle; type 2, the nerve penetrates the lower part of the inferior constrictor muscle; type 3, the nerve runs deep to the inferior constrictor muscle. The type 3 variant may account for the fact that many authors state that the nerve could not be identified in the region of the upper pole of the thyroid gland during thyroid surgery.

**D Selvan** scheme: type 1a, within 1 cm from the entry of the vessels into the gland either anterior or intertwined with the STV or within 3 cm from the cricoid cartilage; type 1b, posterior to the vessels, within 1 cm from the entry of the STV close to the insertion of the CTM; type 2, within 1–3 cm from the entry of the STV into the gland, or within 3–5 cm from the cricoid cartilage; type 3, 3–5 cm from the entry of the STV into the gland, or more than 5 cm from the cricoid cartilage



**Table 1** TOETVA tips and tricks classification for superior thyroid gland pole dissection

N	Surgical advice	Feedback
1	Patient in supine position, slight neck extension, 15°–30° Trendelenburg	Better direct access to the neck organs (see Fig. 6)
2	First assistant (camera holder), sitting on the left	Enhance maneuverability
3	5 mm endoscope	Universal port side use
4	30–45° endoscope	Better view than 0° scope (see Fig. 3)
5	Flexible endoscope	Greater area of neck air pocket visualized In general, flexible instrument for endoscopic surgery appears to offer advantages over conventional rigid ones
6	> 30 cm endoscopic instruments length	Decrease instruments & hands hindrance (see Fig. 2)
7	Articulating instrument	Enhancement of dexterity and ergonomics
8	Neck air pocket	Laterally, the dissection is continued up to the medial border of the sternocleidomastoid muscle on both sides to increase maneuverability
9	Retract ports up to the limit with the lower jaw edge	Improved endoscopic vision Enhance maneuverability
10	Strap muscles are retracted laterally by external hanging suture	The suture and traction is exercised in the cranial 1/3 of the pre-thyroid muscle (see Fig. 7)
11	Thyroid isthmectomy	Facilitates grabbing the thyroid gland Aid dissection and exposure of the Jolles space Simplify upper pole mobilization
12	Carefully engrave the sternothyroid muscle cranially	The muscles are incised until complete exposure of the superior pole of the thyroid gland This is an important maneuver also for the management of bleeding with cranial retraction of the superior thyroid vessels
13	Tract the thyroid upwards and laterally	To protect the EBSLN and the cricothyroid muscle Better vessels exposure
14	Nerve monitoring	EBSLN mapping, identification and functional verification (see Figs. 4, 5) Exclude EBSLN near the superior thyroid vessels (Fig. 9)
15	Tie individually the superior thyroid vessels branches	Safety



**Fig. 12** After complete dissection of the superior thyroid pole, the transoral surgeon uses the upper pole for thyroid gland retraction and subsequent identification of the ipsilateral superior parathyroid gland and RLN. We recommend caution in this phase not to excessively pull the upper gland pole due to possible RLN traction injury

pivot point for the instruments in the inferior vestibule and mandible, which reduces the degrees of freedom of the surgical instruments. The application of advances in technology in surgery can make a huge contribution to addressing some of these limitations. To overcome some of these technical difficulties, new handheld devices have been developed, providing improved functionalities. Additionally, precision-driven and articulating instrument tips might be useful for TOETVA [16–18]. In general, these handheld devices claim to offer an enhancement of dexterity, precision, and ergonomics [1].

Finally, the introduction of transoral robotic thyroidectomy (TORT) provides new solutions [16–18]. Using robotic technology to perform this procedure obviates the need for the majority of the maneuvers described in this paper and illustrated in the video. With its robotic articulating instruments, surgeons can perform 3-dimensional movements with 7-degrees of freedom, which enables more precise dissections around the critical structures of the superior thyroid gland pole. The articulated movements of the endo-wrist allow complete resection of the superior pole of the thyroid

**Table 2** How to choose the patient for the *beginner*? Preoperative evaluation for transoral access to the superior thyroid gland pole

N	Comment
1	Small thyroid gland volume To exclude Cernea 2A or 2B
2	Exclude superior pole nodule High thyroid nodule complicate dissection High thyroid nodule not easy to see endoscopically High nodule is difficult to handle when look for the EBSLN
3	Right thyroid lobe nodule Left thyroid lobe is more challenging to dissect for the right hand surgeon because instruments interbreed and laryngeal prominence interferes with the endoscopic vision
4	Female Male patient is more challenging: Tissues are more robust Laryngeal prominence/thyroid cartilage is larger in adult men and interferes with vision and instrumentation
5	BMI Obesity or too short neck will complicate dissection
6	Short and wide basal arch of the mandible Long and narrow basal arch of the mandible increase operative time and decrease maneuverability
7	CT scan Preoperative CT scan is useful for surgical and anatomical planning of the superior thyroid gland pole

251 gland. The benefits of articulation further stand out in  
252 patients in whom the instruments can easily curve over the  
253 acutely angled thyroid cartilage to steadily retract the thy-  
254 roid tissue. In addition, the surgeon's view under a robotic  
255 camera is greatly enhanced with a high-resolution, 3-dimen-  
256 sional display, which is fully controlled by the surgeon. In  
257 TORT, no modifications to the standard TOETVA technique  
258 are required, except for the additional fourth robotic arm  
259 through the axilla. The supplementary arm through the axil-  
260 lary port enables counter-traction of peri-thyroid and peri-  
261 neural tissues that enhance the fine and precise dissection of  
262 the superior thyroid gland pole.

## 263 Conclusion

264 We present prevention strategies, which are illustrated in  
265 a video technique guide, that are safe, technically feasible,  
266 and add minimal time to the approach to the superior thyroid  
267 gland pole structures in TOETVA. Management of the upper  
268 thyroid pole structures includes: (a) use of a 5 mm/30°–45°  
269 endoscope; (b) retraction ports up to the limit of the inferior  
270 edge of the jaw; (c) lateral retraction of 1/3 of the cranial  
271 strap muscles; (d) isthmectomy; (e) sectioning the sternothy-  
272 roid muscle cranially for 1 cm; (f) retraction of the thyroid  
273 upwards and laterally; (g) monitoring the external branch  
274 of the superior laryngeal nerve; and (h) sealing individual  
275 vessel branches.

276 These techniques warrant investigation in a thoughtful,  
277 prospective manner, but are supported by existing data and  
278 a compelling clinical rationale.

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and/or analysis and interpretation of data; (2) Authors participate in  
drafting the article or revising it critically for important intellectual  
content; and (3) Authors give final approval of the version to be pub-  
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tive support: DG; SH, Collection and assembly of data: PA; WT, Data  
analysis and interpretation: ZD; WT, Manuscript writing: All authors,  
Final approval of manuscript: All authors.

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## 296 Compliance with ethical standards

**Disclosures** Daqi Zhang, Tie Wang, Hoon Yub Kim, Ping Wang, Gian-  
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