Current Otorhinolaryngology Reports (2019) 7:219–224
https://doi.org/10.1007/s40136-019-00248-8

TRANSORAL THYROID AND PARATHYROID SURGERY (R TUFANO AND G DIONIGI, SECTION EDITORS)

Transoral Robotic Thyroidectomy: the New Era of Remote-Access Surgery for Thyroid Disease

Ji Young You[1] · Hoon Yub Kim[1] · Gianlorenzo Dionigi[2] · Ralph P. Tufano[3]

Published online: 3 July 2019

Abstract

Purpose of Review We present a comprehensive overview on the development of robotic transoral thyroidectomy, and highlight major challenges in adoption.

Recent Findings Transoral robotic thyroidectomy (TORT) is the newest remote access approach to remove the thyroid gland and draws attention because of its cosmetic excellence. The principal advantage of TORT is that the flap dissection area is comparatively small to other remote-access methods and the lip wounds disappear over time resulting in excellent cosmesis.

Summary TORT could be done safely in the patients with appropriate selection by an experienced surgeon in robotic thyroidectomy. It serves as a potential alternative surgical approach for thyroidectomy when patients are concerned about a neck scar.

Keywords Transoral robotic thyroidectomy · Transoral thyroidectomy · Thyroidectomy · Thyroid carcinoma · Thyroid nodule

Introduction

Thyroidectomy is the standard for the treatment of organ-confined disease in patients with thyroid cancer and for some benign thyroid disease conditions. The surgical approach has changed significantly with the advent of endoscopic and minimally invasive surgical principles in the last 20 years [1–3]. Reported advantages and disadvantages of remote access endoscopic thyroidectomy are controversial. Some critics claim that it has very limited indications, more surgical trauma, flap dissection, longer operative times, and technical difficulties. Proponents claim that despite these facts, some advantages have been shown and that previously described difficulties have been overcome [4, 5].

In fact, minimally invasive and remote access techniques have continually evolved [6].

Furthermore, in order to improve endoscopic thyroidectomy results, novel approaches, technology, and adjuncts have all been developed and applied. The aim is not only to improve the cosmetic result, but also to decrease the morbidity of the procedures [7, 8].

This evolution helped lead to, a new endoscopic, median approach to the thyroid gland, without leaving visible incisions, i.e., the transoral vestibular approach [9].

Robotic thyroidectomy on the other hand has been a challenge for thyroid surgical community, starting with the proposal of different approaches (direct neck, transaxillary, and transareolar) initially described for endoscopy and then robot-assisted [10].

For the transoral vestibular approach, robotic surgery has come up with good results [11–15].

The transoral robotic technique has given rise to a new concept of minimally invasive surgical thyroid approach and the concomitant expansion of new instrumentation, technology, ports, optics, and mechanisms of retraction [16].

Herein, we present a comprehensive overview on robotic transoral vestibular approach thyroidectomy (TORTVA) [17–18].

This article is part of the Topical Collection on *Transoral Thyroid and Parathyroid Surgery*

✉ Hoon Yub Kim
hoonyubkim@korea.ac.kr

[1] Department of Surgery, KUMC Thyroid Center, Korea University College of Medicine, Korea University Hospital, Inchon-ro 73, Seongbuk-gu, Seoul 06966, South Korea

[2] Division for Endocrine and Minimal Invasive Surgery, Department of Human Pathology in Adulthood and Childhood "G. Barresi', University Hospital "G. Martino", University of Messina, Messina, Italy

[3] Department of Otolaryngology—Head and Neck Surgery, The Johns Hopkins University School of Medicine, Baltimore, MD, USA

We also report on the evolution of robotic platforms through the arrival of new proposals for the robot. Also we discuss the results in the literature, with a comparison of conventional and robotic thyroid techniques.

Indications and Contraindications

A strict and careful patient selection is of utmost importance to ensure a good outcome for transoral robotic thyroidectomy. Recently, due to its ability of having full access of the contralateral lobe and central compartment, this type of surgery has been extended to total thyroidectomy with central lymph node clearance for patients with thyroid cancer [19]. One of the greatest limitations is the size of the nodule.

Nevertheless, as the experience continues to grow with transoral robotic thyroidectomy, so do the inclusion and exclusion criteria, and it is well recognized that increasingly advanced disease may be amenable to this approach as experience is accumulated [7].

Indications for transoral robotic thyroidectomy can be a benign thyroid nodule, such as a large thyroid cyst, single-nodular goiter, or multinodular goiter (single/largest nodule < 6 cm in size on preoperative ultrasound). And also it can be for papillary thyroid carcinoma (< 4 cm in size and without evidence of extensive lymph node metastasis on preoperative ultrasound) and follicular neoplasm (Table 1).

Absolute contraindications for transoral robotic thyroidectomy are the patients who cannot tolerate general anesthesia, poorly differentiated thyroid cancer, undifferentiated thyroid cancer, or locally advanced thyroid cancer with tracheal/esophageal invasion or thyroid cancer with N1b lymph node involvement or posterior extrathyroidal extension. Patients who have had previous history of neck surgery, previous history of neck radiation, or presence of oral abscess are contraindicated (Table 1).

Preoperative Requirements

As in all endoscopic procedures, transoral robotic thyroidectomy also requires good preoperative planning. Preoperative factors considered by the surgical team include a thorough preoperative work-up, laryngoscopic vocal cord assessment, administration of prophylactic antibiotics, and checking instrumentation.

A preoperative thorough work-up should include a thyroid ultrasound and/or a CT scan of the neck. All patients should receive an ultrasound-guided fine-needle aspiration biopsy before surgery in planning the appropriate procedure. It is important to obtain informed consent from all patients, including a review of the novel nature of this procedure and the associated risks. Additionally, the fact that the daVinci robot is not approved by the USA Food and Drug Administration (FDA) for this approach needs to be reviewed with each patient and included in the consent [7].

Since being a clean-contaminated surgery, the transoral technique carries the risk of infection in the anterior neck region. The three vestibular incisions result in a new communication between the oral cavity and the neck. Hence, a normally aseptic operation may become a potentially infectious surgical intervention due to the spreading of oral microflora during neck exploration [20]. To optimize oral hygiene, we feel it is advisable for patients to undergo dental care prior to surgery to include gargling with chlorhexidine mouth wash, twice a day. Preoperative preparation must include prophylactic antibiotics to cover oral flora and preoperative laryngoscopic vocal cord assessment.

Every effort must be made to confirm all instrumentation necessary prior to surgery. A list of required robotic and conventional endoscopic equipment, including instruments, drapes, cannulas, endoscopes, energy-based devices, electrosurgical unit, camera system, recorder system, irrigation system, positioners, suture materials, nerve monitor, protective sponges, and general instruments, should be available.

Table 1 Indications and contraindications for transoral robotic thyroidectomy

Indications	Contraindications
• Benign thyroid nodule, such as a large thyroid cyst, single-nodular goiter, or multinodular goiter (single/largest nodule < 6 cm in size on preoperative ultrasound)	• Patients unfit for surgery and who cannot tolerate general anesthesia
• Papillary carcinoma (< 4 cm in size and without evidence of extensive lymph node metastasis on preoperative ultrasound)	• Poorly differentiated thyroid cancer
• Follicular neoplasm	• Undifferentiated thyroid cancer
	• Locally advanced thyroid cancer with tracheal/esophageal invasion
	• N1b lymph node involvement
	• Posterior extrathyroidal extension
	• Previous history of neck surgery
	• Previous history of neck radiation
	• Presence of oral abscess

Procedures

Working Space Formation

The patient is positioned supine and placed under general anesthesia. After they are intubated with nerve monitoring endotracheal electromyogram tube, the neck is placed in slight extension. Three incisions are made in the gingival-buccal sulcus; one in the midline, a 1.5-cm-length inverted U shape incision approximately 1 cm above the frenulum labii inferioris, and two 0.5-cm-length incisions laterally in the mucosa near the angle of mouth (Fig. 1a). The central incision is addressed first. Once the periosteum is identified through the midline incision, a submental subplatysmal pocket is formed by blunt dissection with mosquito and Kelly forceps to create a tunnel from the edge of the mandible to lower neck by injecting 1:200,000 epinephrine saline mixture for hydrodissection of the subplatysmal plane. Then, blunt dissection with an 8-mm-tipped vascular surgical tunneler is gently performed to elevate the platysma off the strap muscles all the way down towards the suprasternal notch [20] (Fig. 1b).

Once an adequate flap is created, the endoscope cannula is inserted. CO_2 insufflation (5–7 mmHg) is introduced and maintained via the central port. A similar blunt dissection is also performed through the two lateral incision sites, allowing insertion of the instrument cannulae into the subplatysmal working space. Next, standard laparoscopic instruments—a suction electrocautery and an ultrasonic-shears—are used to elevate the platysma from the level of the mandible to the sternum inferiorly and laterally to the sternocleidomastoid muscles. Subsequently, an 8-mm bariatric trocar can be inserted through an incision made along the patient's right axillary fold into the subplatysmal working space for the third arm of the robot to add counter-traction of the strap muscles or perineural tissue during the operation and for later insertion of the closed suction drain if desired [7]. A few vicryl stitches can be used to help retract the subplatysmal flap superiorly in order to create a larger working space [20].

Docking Stage

Once the working space formation is complete, the robotic system is deployed. The cannulae are docked into the robotic arms, starting with the central cannula to secure the position of the endoscope (30°, down facing). A Maryland dissector and the Harmonic scalpel are inserted into the left and right ports, respectively [20].

Console Stage

Dissection in the midline raphe is performed to separate the strap muscles. The strap muscles are dissected off the thyroid gland, exposing the lobe(s) of interest. The pyramidal lobe is dissected off from the thyroid cartilage if it is identified, and isthmusectomy is performed subsequently [20]. Once the thyroid lobe is freed off the trachea medially, the superior pole is addressed. Careful dissection of the superior lobe is performed ligating one vessel at a time. The superior parathyroid gland is identified and preserved first. Then the thyroid lobe is retracted inferiorly to facilitate the identification of the recurrent laryngeal nerve (RLN) at its entry point into the larynx around the cricothyroid articulation [7]. Once the RLN is identified and carefully preserved, the Berry's ligament is addressed. The dissection is then carried out inferiorly to identify and to preserve the inferior parathyroid gland. Once the inferior lobe is freed off of its surrounding soft tissue, hemithyroidectomy is complete [20]. The contralateral lobectomy can be completed at the same time if necessary without any additional incision.

Ipsilateral central compartment dissection with tracing the RLN into the thoracic inlet may be followed if it is needed, and the lympho-adipose tissue in the central compartment can be retrieved en bloc with the resected thyroid lobe [20]. The nerve stimulator probe is used to stimulate the RLN and to test neurophysiologic integrity during and after the procedure [7]. The specimen can be removed through the additional axillary incision in an endoscopic plastic bag without any disruption

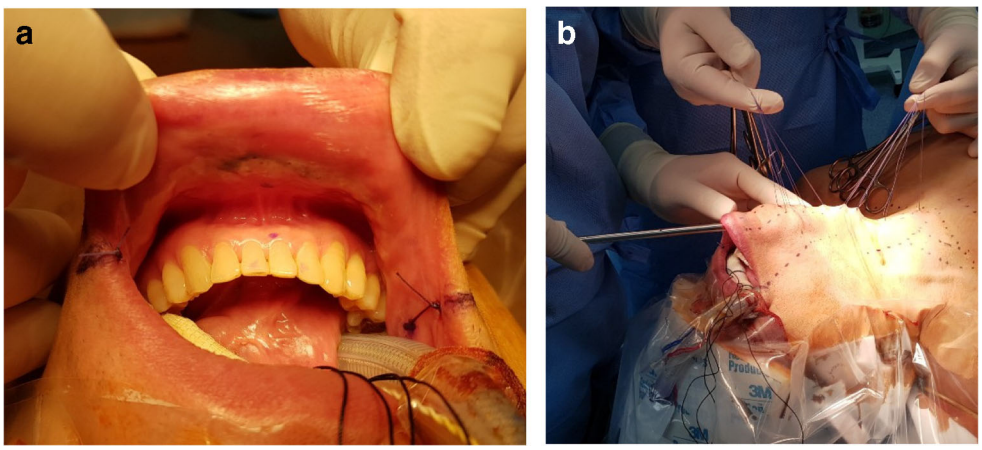

Fig. 1 **a** Location of incisions. **b** Blunt dissection with 8-mm-tipped vascular surgical tunneler

usually. Meticulous hemostasis is achieved and the wound is irrigated. A Jackson Pratt drain, if desired, is inserted through the axillary port and the middle raphe of the strap muscles is re-approximated with a self-locking absorbable suture. The oral vestibule incisions are closed in a layer with absorbable sutures. A compression dressing is placed across the neck and chin after the patient has been extubated [7].

Postoperative Management

Patients can be permitted to sips of water 4 h after surgery. A soft bland diet and ice cream intake are recommended in the evening of the operation day, and the normal regular diet can be initiated on the postoperative first day. Intraoral stitches are removed in the second week after discharge at the outpatient clinic.

Results

The few studies and short series available until now may be the result of early adoption in the application of robotics for the transoral thyroidectomy approach [1–21]. Only a few small series have been reported, and the results have not been fully evaluated. The new robotic platform, the da Vinci Xi (surgical intuitive, Sunnydale, CA, USA), shows that it is clear that the long awaited evolution of robotic technologies for thyroid surgery has begun, and we must not lose this momentum [7].

Working through endoscopy, the reduction of the workspace is evident. It inevitably leads to highly complex procedures and higher surgical skill requirements as well as the collision of instruments, limited freedom of movement, and display of difficulties. The evolution strategy of a robotic transoral approach should be considered in terms of five main aspects: trocars, instruments, reduction of tremor, mechanisms of retraction and display as strategies to overcome technical problems, and improve the performance of the technique of transoral thyroidectomy [8]. Another important advance in the development of robotic thyroidectomy is the appearance of modified curved instruments, articulated and flexible, allowing the proper triangulation and intracorporeal mobility. The wide range of movements that the surgical system da Vinci Xi offers is widely known as one of its advantages, which in theory reduces internal and external instrument collision.

However, this reputation is not entirely justified; the surgical system da Vinci is characterized by considerable size and volume, and initial platforms were not clearly developed for these procedures. Despite these factors, surgeons have performed transoral thyroidectomies with the da Vinci System and have demonstrated in the medical literature that it is feasible and safe, providing standardization of the technique.

On the other hand, after exploring different surgical approaches (transaxilla, transareola, retroauricular, robotic even with changes to the platform), the transoral robotic thyroidectomy has becoming popular [7, 8].

Kim et al. first reported the technique to be feasible and safe for selected patients after technical refinements, and that it can be a potential alternative approach for scarless thyroid surgery [5]. The authors describe results for the transoral robotic thyroid surgery at Korea University Hospital [5]. The author used three intraoral ports and a single axillary port for the system's four robotic arms. The study comprehended twenty-four female patients (mean age 39.6 ± 11.6 years, mean tumor size 1.0 ± 1.3 cm), who underwent unilateral thyroid lobectomies with or without ipsilateral central neck dissection. Twenty patients had papillary thyroid carcinomas (PTC), three had benign nodules, and one had a follicular thyroid carcinoma. The mean surgical time was 232 ± 41 min; the mean hospital stay was 3.3 ± 0.8 days as in Korea it is customary to stay as an inpatient even for standard transcervical thyroidectomy. The number of retrieved central lymph nodes in the PTC patients was 4.7 ± 3.2. There were no reports of transient or permanent vocal cord palsy, recurrence, or mortality during the median follow-up period of 16.8 months. Paresthesias of the lower lip and the chin due to mental nerve injury were observed in nine of the first 12 patients (six transient, three permanent), but no further reports of paresthesia were recorded after patient 12, when the locations of the intraoral incisions were modified and placed closer to the oral commissure [5].

Transoral robotic thyroidectomy may be an alternative approach for patients who prefer a scar-free thyroidectomy. In one recent study, the authors affirmed that the TORT procedure could be performed safely and showed comparable outcomes with axillo-breast approach (BABA) robotic thyroidectomy in selected patients [2]. The surgical outcomes of a single surgeon's initial cases of transoral robotic thyroidectomy were compared with the surgeon's initial cases of a BABA robotic thyroidectomy. Each group comprised 50 patients. Operative time for total thyroidectomy was shorter, the pain scores were lower, and hospital stays were shorter in the transoral robotic thyroidectomy group than in the BABA robotic thyroidectomy group. There were no significant differences between groups in either vocal cord palsy or hypoparathyroidism rates. There were 9 cases of mental nerve injury in the first 12 cases of transoral robotic thyroidectomy, but none subsequently [2].

Advantages and Disadvantages

Advantages

The major advantage of transoral thyroidectomy lies in cosmesis. Transoral thyroidectomy is cosmetically superior to any other approaches that leave small scars on the neck or

transfer scars to the other part of neck because intraoral scars are not only merely hidden but also heal in 2 or 3 weeks and completely disappear in a few months [5]. In addition, transoral thyroidectomy does not require extensive flap dissection. Dissection extent of transoral thyroidectomy is similar to that of conventional open thyroidectomy which covers from sternal notch to thyroid cartilage level, and it is much smaller than other remote-access approaches; the two most popular approaches—gasless transaxillary and bilateral axillo-breast approach—require wide flap dissection at the axilla and upper chest, respectively. The smaller dissection area in transoral thyroidectomy might result in little sensory loss or postoperative pain related to flap dissection, which is more significant in the other remote-access approaches [20].

TORT has some additional technical merits. First, complete resection of pyramidal lobe or upper pole of the thyroid gland with rigid endoscopic instruments might be hampered. With the robot, surgeons can approach the deep and upper part of the thyroid gland more easily using the articulated movement of the robot in TORT. Second, the robotic system has tremor-filtering system and enables surgeons to perform fine and safe dissection around the critical structures such as parathyroid glands or RLNs. In addition, the fourth articulating instrument from the axilla enables the counter-traction of strap muscles or perineural tissue, which result in the precise and arguably more complete dissection especially around Berry's ligament. Finally, the operative view of TORT is superior to that of endoscopic transoral thyroidectomy. TORT offers a magnified three-dimensional operative view, in comparison with endoscopic transoral thyroidectomy [20].

Disadvantages

One of the most serious complications of transoral thyroidectomy, which was encountered in the initial developmental era, was the mental nerve injury. The mental nerve is a sensory nerve, which innervates the skin of the lower lip and the chin; therefore, patients would suffer from numbness around the lower lip and chin if the mental nerve was injured. However, this complication was resolved by modifying port placement, and after the initial 12 cases, and no more mental nerve injuries have occurred since.

Minor complications, such as bruising on the zygomatic region and tearing of oral commissures, from excessive force of robotic arm movements were observed initially as well [5]. However, zygomatic bruising could be prevented with careful monitoring by the surgical assistants at the patient's side along with a protective sponge application over zygoma [20]. Protection sutures around the oral commissures can be placed to help prevent the tearing at the oral commissure.

The transoral technique may bring in the risk of infection in the anterior neck region. A normally aseptic operation may become a potentially infectious surgical intervention due to the spreading of oral microflora during neck exploration [20]. Yet, animal experiments performed in advance of the clinical study did not show any severe infections, and there were no seromas in the operative field after drain insertion. In the clinical settings, infections of the anterior neck area or of the oral wounds after transoral endoscopic surgery could be prevented by a single dosage of preoperative intravenous prophylactic antibiotic administration along with a drain to the operative field through the axillary port.

Conclusions

TORT could be done safely in the patients with appropriate selection by an experienced surgeon in robotic thyroidectomy. It serves as a potential alternative surgical approach for thyroidectomy when patients are concerned about a neck scar.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

1. Dionigi G, Wu CW, Tufano RP, Rizzo AG, Anuwong A, Sun H, et al. Monitored transoral endoscopic thyroidectomy via long monopolar stimulation probe. J Vis Surg. 2018;4:24. https://doi.org/10.21037/jovs.2017.12.25.
2. Chai YJ, Kim HY, Kim HK, Jun SH, Dionigi G, Anuwong A, et al. Comparative analysis of 2 robotic thyroidectomy procedures: transoral versus bilateral axillo-breast approach. Head Neck. 2017. https://doi.org/10.1002/hed.25034.
3. Dionigi G, Chai YJ, Tufano RP, Anuwong A, Kim HY. Transoral endoscopic thyroidectomy via a vestibular approach: why and how? Endocrine. 2018;59(2):275–9. https://doi.org/10.1007/s12020-017-1451-x.
4. Chai YJ, Chung JK, Anuwong A, Dionigi G, Kim HY, Hwang KT, et al. Transoral endoscopic thyroidectomy for papillary thyroid microcarcinoma: initial experience of a single surgeon. Ann Surg Treat Res. 2017;93(2):70–5. https://doi.org/10.4174/astr.2017.93.2.70.
5. Kim HY, Chai YJ, Dionigi G, Anuwong A, Richmon JD. Transoral robotic thyroidectomy: lessons learned from an initial consecutive series of 24 patients. Surg Endosc. 2018;32(2):688–94. https://doi.org/10.1007/s00464-017-5724-5.
6. Anuwong A, Sasanakietkul T, Jitpratoom P, Ketwong K, Kim HY, Dionigi G, et al. Transoral endoscopic thyroidectomy vestibular approach (TOETVA): indications, techniques and results. Surg Endosc. 2018;32(1):456–65. https://doi.org/10.1007/s00464-017-5705-8.
7. Richmon JD, Kim HY. Transoral robotic thyroidectomy (TORT): procedures and outcomes. Gland Surg. 2017;6(3):285–9. https://doi.org/10.21037/gs.2017.05.05.

8. Anuwong A, Kim HY, Dionigi G. Transoral endoscopic thyroidectomy using vestibular approach: updates and evidences. Gland Surg. 2017;6(3):277–84. https://doi.org/10.21037/gs.2017.03.16.
9. Dionigi G, Lavazza M, Wu CW, Sun H, Liu X, Tufano RP, et al. Transoral thyroidectomy: why is it needed? Gland Surg. 2017;6(3):272–6. https://doi.org/10.21037/gs.2017.03.21.
10. Chang EHE, Kim HY, Koh YW, Chung WY. Overview of robotic thyroidectomy. Gland Surg. 2017;6(3):218–28. https://doi.org/10.21037/gs.2017.03.18.
11. Dionigi G, Tufano RP, Russell J, Kim HY, Piantanida E, Anuwong A. Transoral thyroidectomy: advantages and limitations. J Endocrinol Investig. 2017;40(11):1259–63. https://doi.org/10.1007/s40618-017-0676-0.
12. Dionigi G, Bacuzzi A, Lavazza M, Inversini D, Boni L, Rausei S, et al. Transoral endoscopic thyroidectomy: preliminary experience in Italy. Updat Surg. 2017;69(2):225–34. https://doi.org/10.1007/s13304-017-0436-x.
13. Dionigi G, Lavazza M, Bacuzzi A, Inversini D, Pappalardo V, Tufano RP, et al. Transoral endoscopic thyroidectomy vestibular approach (TOETVA): from A to Z. Surg Technol Int. 2017;30:103–12.
14. Russell JO, Noureldine SI, Al Khadem MG, Chaudhary HA, Day AT, Kim HY, et al. Transoral robotic thyroidectomy: a preclinical feasibility study using the da Vinci Xi platform. J Robot Surg. 2017;11(3):341–6. https://doi.org/10.1007/s11701-016-0661-1.
15. Dionigi G, Bacuzzi A, Lavazza M, Inversini D, Pappalardo V, Boni L, et al. Transoral endoscopic thyroidectomy via vestibular approach: operative steps and video. Gland Surg. 2016;5(6):625–7. https://doi.org/10.21037/gs.2016.12.05.
16. Clark JH, Kim HY, Richmon JD. Transoral robotic thyroid surgery. Gland Surg. 2015;4(5):429–34. https://doi.org/10.3978/j.issn.2227-684X.2015.02.02.
17. Lee HY, Richmon JD, Walvekar RR, Holsinger C, Kim HY. Robotic transoral periosteal thyroidectomy (TOPOT): experience in two cadavers. J Laparoendosc Adv Surg Tech A. 2015;25(2):139–42. https://doi.org/10.1089/lap.2014.0543.
18. Lee HY, You JY, Woo SU, Son GS, Lee JB, Bae JW, et al. Transoral periosteal thyroidectomy: cadaver to human. Surg Endosc. 2015;29(4):898–904. https://doi.org/10.1007/s00464-014-3749-6.
19. Razavi CR, Fondong A, Tufano RP, Russell JO. Central neck dissection via the transoral approach. Ann Thyroid. 2017;2(5). https://doi.org/10.21037/aot.2017.10.02.
20. Kim HY. Transoral robotic thyroidectomy. Curr Surg Rep. 2017;5:19.
21. Lee HY, Hwang SB, Ahn KM, Lee JB, Bae JW, Kim HY. The safety of transoral periosteal thyroidectomy: results of Swine models. J Laparoendosc Adv Surg Tech A. 2014;24(5):312–7. https://doi.org/10.1089/lap.2013.0218.