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Transoral Robotic Thyroidectomy

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Abstract
Purpose of Review Transoral approach is nowadays gaining the enormous attention among the thyroid surgeons, as it showed definite merits over the previously developed remote-access approaches for thyroidectomy, such as the ideal cosmetic outcome without remaining the postoperative scars, and the lesser dissection of the flap resulting in the decreased operation time and lesser postoperative pain.
Recent Findings Instead of using the conventional endoscopic operation apparatus and instruments, we could successfully introduce the robotic surgical system to this novel surgical approach, and, in turn, could have the optimal surgical outcomes enhanced by the unique three-dimensional operative vision and multiple articulating instruments, after overcoming some trials and errors encountered during the initial developmental era.
Summary I herein describe the procedures of transoral robotic thyroidectomy (TORT) which we uniquely developed, and show my personal opinion on the advantages and disadvantages of the TORT.

Keywords Transoral thyroidectomy · Transoral endoscopic thyroidectomy · Transoral robotic thyroidectomy · Minimally invasive thyroidectomy

This article is part of the Topical collection on *Robotic Surgery*.

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Introduction

Various endoscopic approaches for thyroidectomy have been developed to avoid the visible scar on the neck since the first endoscopic parathyroid surgery was reported in 1996 [1]. There are a number of studies reporting feasibility and safety of endoscopic thyroidectomy with large series of patients [2, 3]. However, these existing endoscopic or robotic methods for thyroidectomy have been criticized for not being truly minimally invasive, since they require extensive dissection of the chest and neck region plus the long operative time. Many surgeons believe that these procedures are more invasive than conventional open thyroid surgery, and thus research has continued on less invasive methods. Transoral thyroid surgery was developed to fill this need for a truly minimally invasive approach.

Historically, Wilhelm et al. [4] reported the first human series of transoral thyroidectomy in eight patients. Nakajo et al. [5] reported the results of clinical trials as well. They performed transoral endoscopic thyroidectomy named as TOVANS without gas insufflation. These studies inspired us to develop our new mandibular periosteal approach for thyroid surgery, which we named as the transoral periosteal thyroidectomy (TOPOT). Through experimentation with cadavers, we defined anatomical spaces and developed a mandibular periosteal approach that does not limit the movement of endoscopic instruments and reduces the risk of injury to the upper teeth, nose, and mental nerves [6•].

To develop the feasible and ideal anatomical approach, and then to evaluate the clinical safety before the application of the method to real human beings, TOPOTs were performed in seven fresh human cadavers and ten live pigs. Total thyroidectomies were successfully performed in all these cadavers and the pigs. The recurrent laryngeal nerves could be identified and preserved in all cadavers using TOPOT. Median operative time was 89.8 (55–132) minutes. In the swine experiments, we could find no serious intra/postoperative complication, just except the postoperative fluid collection in the operative space when the drain was not placed in it [7].

More recently, large-volume institutes started to adopt robotic system to endoscopic procedures and the number of robotic thyroidectomy increased sharply despite high cost [8, 9]. It is believed that this is mainly because surgeons prefer magnified three-dimensional operative view offered by robotic system, which enables surgeons to perform surgery more safely and precisely with less fatigue. In turn, robotic thyroidectomy has substituted endoscopic thyroidectomy and gradually became a procedure of choice recently.

For these reasons, on the basis of the successful cadaver and animal trials, and then after the approval of the IRB, we started the robotic transoral thyroidectomy procedures using our periosteal approach in the patients, which, we believe, would be the first series of robotic transoral thyroidectomy in live human beings [10••].

Procedures of Transoral Endoscopic Thyroidectomy (TOET)

Once the patient is placed under general anesthesia, the neck is placed in slight extension. Three incisions are made in the gingival-buccal sulcus: one in the midline, approximately 2 cm above the frenulum labii inferioris, and two laterally near the angle of mouth. The central incision is addressed first. A submental subplatysmal pocket is formed to create a tunnel towards the edge of the mandible. Blunt dissection is performed to elevate the platysma off the strap muscles all the way down towards the suprasternal notch. This blunt dissection is facilitated via injections of saline mixed with epinephrine into the subplatysmal layer. Once an adequate flap is created, the endoscope (30°, down facing) cannula is inserted. CO_2 insufflation (8–10 L/min) is introduced and maintained via the central port. A similar blunt dissection is also performed from the two lateral incision sites allowing insertion of the trocars into the subplatysmal working space. A few vicryl stitches can be used to help retract the subplatysmal flap superiorly in order to create a larger working space.

Once the working space formation is complete, the 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 the thyroid cartilage and isthmusectomy is performed. 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. The thyroid lobe is retracted inferiorly to facilitate the identification of the recurrent laryngeal nerve (RLN) at its entry point into the larynx. Once the RLN is identified and carefully preserved, the Berry's ligament is addressed. The dissection is then carried out inferiorly preserving the inferior parathyroid gland. Once the inferior lobe is free off of its surrounding soft tissue, hemithyroidectomy is complete. 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. The specimen can be removed through the midline oral incision or through the additional axillar incision which later can be occupied by the closed suction drain.

Steps of Transoral Robotic Thyroidectomy (TORT)

Working Space Formation

Once the patient is placed under general anesthesia, the neck is placed in slight extension. Three incisions are made in the gingival-buccal sulcus: one in the midline, approximately 2 cm above the frenulum labii inferioris, and two laterally near the angle of mouth. The central incision is addressed first. A submental subplatysmal pocket is formed to create a tunnel towards the edge of the mandible. Blunt dissection is performed to elevate the platysma off the strap muscles all the way down towards the suprasternal notch. This blunt dissection is facilitated via injections of saline mixed with epinephrine into the subplatysmal layer. Once an adequate flap is created, the endoscope (30°, down facing) cannula is inserted. CO_2 insufflation (8–10 L/min) is introduced and maintained via the central port. A similar blunt dissection is also performed from the two lateral incision sites allowing insertion of the instrument cannulae into the subplatysmal working space (Fig. 1). A few vicryl stitches can be used to help retract the subplatysmal flap superiorly in order to create a larger working space.

Docking Stage

Once the working space formation is complete, the robotic system is deployed. The cannulae are inserted into the robotic arms, starting with the central cannula to secure the position of the endoscope. A Maryland dissector and the Harmonic scalpel are inserted into the left and right ports, respectively (Fig. 2).

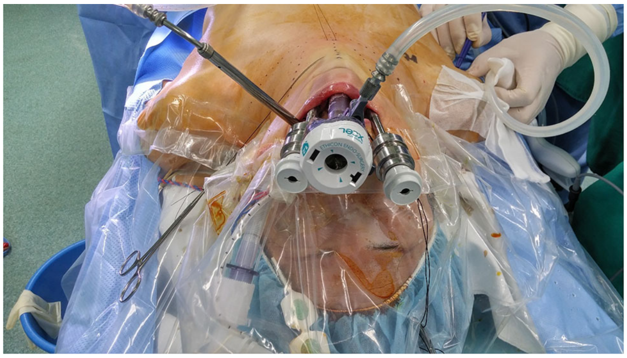

Fig. 1 Placement of trocars in TORT

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 the thyroid cartilage and isthmusectomy is performed. 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. The thyroid lobe is retracted inferiorly to facilitate the identification of the recurrent laryngeal nerve (RLN) at its entry point into the larynx. Once the RLN is identified and carefully preserved, the Berry's ligament is addressed. The dissection is then carried out inferiorly preserving the inferior parathyroid gland. Once the inferior lobe is free off of its surrounding soft tissue, hemithyroidectomy is complete.

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. The specimen can be removed through the midline oral incision or through the additional axillar incision, which later can be occupied by the closed suction drain, in the plastic bag.

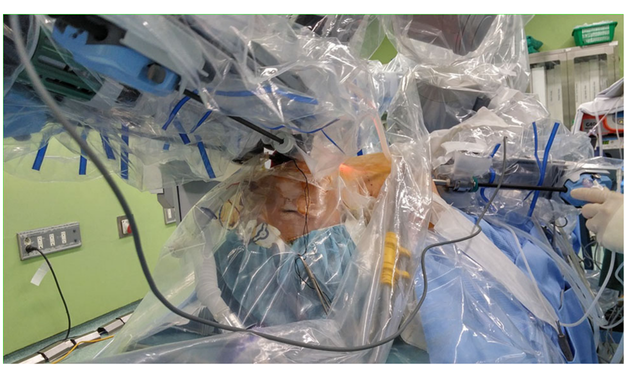

Fig. 2 Placement of trocars and socked robotic arms during TORT procedure

Advantages and Disadvantages of Transoral Robotic Thyroidectomy (TORT)

The main advantage of transoral thyroidectomy lies in cosmesis. Transoral thyroidectomy is cosmetically superior to any other approaches which 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. 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, requires additional wide flap dissection at axilla and upper chest, respectively. Small dissection area in transoral thyroidectomy might cause little sensory loss or postoperative pain related to flap dissection, which is significant in the other remote-access approaches. Potential benefits from small dissection area should be evaluated in the prospective setting in the near future.

In addition to general advantages of transoral thyroidectomy, TORT has several technical merits. First, complete resection of pyramidal lobe or upper pole of the thyroid gland with rigid endoscopic instruments might be hampered when they are highly or deeply located because the approach direction is cephalad to caudal. On the other hand, surgeons can approach deep upper part of thyroid glands more easily using articulated movement of endowrist 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, operative view of TORT is superior to that of endoscopic transoral thyroidectomy. TORT offers magnified three-dimensional operative view, whereas monitor is set at the feet-side of a patient and relatively far from the surgeon's sight in endoscopic transoral thyroidectomy (Fig. 3).

One of the most serious complications of transoral thyroidectomy, which was encountered in the initial developmental era, was the mental nerve injury. Mental nerve is a sensory nerve, which innervates the skin of the lower lip and the chin; therefore, patients would have permanent numbness around lower lip and chin if injured. In fact, mental nerve injury had been an obstacle during our initial experience. However, we could avoid this complication by modifying port placement, and we had no more after the initial 12 cases. Mental nerve emerges from the mental foramen in the mandible and branches into upper and lower branches. Mental foramen is generally located

Fig. 3 Operative room view during TORT

below canine root, and mental nerve runs medially after branching. Therefore, the nerve is less likely to be injured when the ports are placed more laterally and more distal to canine root. We moved port insertion sites accordingly, and could avoid nerve injury.

We also had minor complications such as bruise on zygomatic region and tearing of oral commissures. Thereafter, we fix sponges on the zygomatic bones to prevent bruise and assistants at robotic side carefully monitor robotic arm movement to prevent excessive force being applied. Surgeons should always be aware of the range of motion of the robotic arms not to cause physical trauma.

The transoral technique carries 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. Therefore, animal experiments were performed in advance of the clinical study. None of the pigs we operated on developed any severe infections, and there were no seromas in the operative field after drain insertion. In our series, prophylactic antibiotics were given by intravascular injection till the postoperative third day. At the end of the operation, we inserted a drain to the operative field through the axillary port. The drains were removed when the patients were discharged. No patients developed infections of the anterior neck area or of the oral wounds. These results suggest that, if prophylactic antibiotics are given and the drain is inserted, infection after transoral endoscopic surgery can be prevented.

Conclusion

Transoral robotic thyroidectomy may be the good approach for the patients with surgical thyroid diseases pursuing favorable cosmesis. There were some trials and errors during the initial experience, which could be overcome after technical modifications.

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Compliance with Ethics Guidelines

Conflict of Interest The author declares no conflicts of interest relevant to this manuscript.

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.

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