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Scarless Thyroidectomy: Transoral Endoscopic Thyroidectomy by Vestibular Approach

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ABSTRACT:

Scarless thyroidectomy: transoral endoscopic thyroidectomy by vestibular approach

Transoral endoscopic thyroidectomy by vestibular approach (TOETVA) is a minimally invasive, natural orifice transluminal endoscopic surgery (NOTES) technique with no visible scarring. Endoscopic lobectomy or total thyroidectomy can be performed completely under low CO_2 pressure level with the aid of one 10 mm and two 5 mm ports applied from vestibular region through the mouth. Its application is increasing worldwide. It can be safely performed in selected patients in experienced centers. In this study, the development of minimally invasive thyroid surgery, patient selection and exclusion criteria for TOETVA, regional anatomy, surgical technique, preoperative and postoperative care, advantages and disadvantages and possible complications of the procedure will be discussed.

Keywords: Endoscopic thyroidectomy, minimally invasive endoscopic thyroidectomy, scarless thyroidectomy

ÖZET:

İzsiz tiroidektomi: Vestibüler yaklaşımla transoral endoskopik tiroidektomi

Vestibüler yaklaşımla transoral endoskopik tiroidektomi (TOETVA) minimal invaziv, görünür yara izi olmayan naturel orifis transluminal endoskopik cerrahi (Naturel orifice transluminal endoscopic surgery (NOTES) tekniktir. Ağız içinden vestibüler bölgeden uygulanan 1 adet 10 mm ve 2 adet 5 mm port yardımı ile düşük CO_2 basıncı altında tamamen endoskopik olarak lobektomi veya total tiroidektomi uygulanabilir. Dünyada giderek uygulaması artmaktadır. Deneyimli merkezlerde seçilmiş hastalarda güvenli bir şekilde uygulabilmektedir. Bu çalışmada minimal invaziv tiroit cerrahisinin gelişimi, TOETVA için hasta seçimi ve dışlama kriterleri, bölgesel anatomi, ameliyat tekniği, preoperatif ve postoperatif bakım, yöntemin avantajları, dezavantajları ve olası komplikasyonları tartışılacaktır.

Anahtar kelimeler: Endoskopik tiroidektomi, izsiz tiroidektomi, minimal invaziv endoskopik tiroidektomi

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DEVELOPMENT OF MINIMALLY INVASIVE THYROID SURGERY

Minimally invasive surgery involving each branch, from general surgery to neurosurgery, can be regarded as the third major turning point in surgery after asepsis and anesthesia (1). Minimally invasive procedures are not new to arthroscopy, endoscopy and gynecological procedures, and have a history of more than 100 years. Minimally invasive surgery is relatively new and there has been a rapid development in minimally invasive surgery after the first laparoscopic cholecystectomy has been performed 30 years ago. Today, this method has replaced many conventional surgeries, and has become one of the standard treatment approaches (2). Minimally invasive surgery can be defined as the ability of the surgeon to perform the traditional surgical procedure in new ways that allow the surgical field to be minimally traumatized (3).

After Billroth and Kocher, thyroid surgery with transcervical excision has become the standard

approach and most of the thyroid surgeries are performed with Kocher's transverse collar incision. Most of the patients undergoing thyroidectomy are young female patients and the visible scar in the neck region is the undesirable result of surgery for many patients. In this process, many methods have been tried to minimize the visibility and the length of the scar. The surgical procedure referred to as the first minimally invasive procedure in the neck was endoscopic parathyroidectomy performed by Gagner (4) in 1996 with 4 ports of 5 mm, inserted through the neck. From this date on, many methods have been defined in the name of minimally invasive thyroidectomy, such as thyroidectomy with anterior or lateral total endoscopic approach, minimally invasive video-assisted thyroidectomy with open method, non-endoscopic lobectomy with mini-incision (minimally invasive non-endoscopic thyroidectomy) (5-12). The main purpose of these methods is to increase the use of small cervical incision and to improve the associated cosmetic results. However, there is a visible incision scar in the neck region even if it is small.

Endoscopic and robotic methods have been described for the purpose of preventing visible scarring in the neck, by moving the incisions to axilla, breast, chest wall or retroauricular region (13-20). In these methods, although there is no incision at the neck, there is an incision scar that can be seen in other parts of the body. These techniques should not be considered as minimally invasive methods, since entry sites are far away from the thyroid, and subcutaneous dissection in the neck and/or chest within a wider area is required to reach the thyroid. After surgery, patients may feel parasthesia on the skin for a long time (21,22).

Natural orifice transluminal endoscopic surgery (NOTES) is a scar-free surgical technique that can be performed using an endoscope applied through natural orifices, such as the mouth, urethra, vagina or anus. The surgery is completed with an internal incision made through the colon, bladder, vagina or stomach. By this way, external incision and scarring may be avoided (23). Since 2008, transoral endoscopic thyroidectomy with NOTES method has been started to be applied in experimental and clinical studies. Endoscopic transoral thyroid surgery was performed initially with a sublingual and transtracheal approach. These techniques were abandoned after a number of experimental studies and limited cases, because of severe tissue damage, high complication rate, high rate of conversion to open surgery and technical difficulties due to limited movement of the instruments during surgery (24-27). Combined method in which ports were inserted in combination by sublingual and oral vestibular approach was described by other investigators and was named as transoral video-assisted thyroidectomy or endoscopic minimally invasive thyroidectomy (28-31). Due to the difficulty of the technique and the high complication rate, these methods lost their popularity.

Another technique described in transoral endoscopic thyroidectomy is the vestibular approach. Richmon et al. (32) described a transoral robotic-assisted thyroidectomy with a total oral vestibular approach, taking this port in front of the mandibula to increase the limited mobility of the sublingual port used in the combined method in their human cadaver study in 2011. In this method, the ports were close to the gingiva-buccal sulcus. Nokaja et al. (33) in the vestibular approach they applied, made a 2.5 cm incision inferior to the middle of the lower lip to create a dissection area. After dissecting the subplatysmal area, the skin was lifted with 2 Kishner wires and the process was performed without CO_2 insufflation, and named this procedure as transoral video-assisted neck surgery (TOVANS). Transient vocal cord paralysis developed in 1 patient. All of the 8 patients who had undergone the procedure developed parasthesia around the chin, which persisted more than 6 months, suggesting mental nerve injury. In another study, Wang et al. (34) placed their port incisions with a vestibular approach at 10 mm midline near the buccogingival sulcus and 5 mm to lateral as far as possible on both sides. Skin ecchymosis has been reported as a complication in two of the 12 patients in whom the method was applied in the study, and there is no data related to the sensorial complication at the chin. Mental nerve damage is the main problem related with the technique in studies up to now (22).

Anowong (35) published his study he performed in 2014, with 60 cases to whom he performed transoral endoscopic thyroidectomy with a vestibular

approach (TOETVA) with 3 ports, in 2016. The results of this study are encouraging for this technique with minimal complication rates. Anuwong has performed nearly 700 TOETVA surgeries in his own clinic up to now (July 2017, personal interview). From the previous cadaver and animal studies and transoral applications with the subsequent clinical studies, the technical details of the TOETVA method were standardized for the first time (35-37). This technique (TOETVA), which has been started to be implemented by many centers around the world, is becoming quickly more common (38-44).

In our country, this technique has started to be applied in 4 centers, including ours.

TRANSORAL ENDOSCOPIC THYROIDECTOMY BY VESTIBULAR APPROACH

Patient Inclusion and Exclusion Criteria

Because patient safety is a basic criterion for every surgery, patient selection must be done meticulously according to the determined criteria. Since the method has recently been implemented in many centers, these selection criteria should not be compromised until a level of experience has been established. As experience grows and according to the results of the studies on this subject, the selection criteria may change over time. Currently accepted patient selection and exclusion criteria are summarized in Table-1 (22,23,42,45,46).

Table-1: Patient inclusion and exclusion criteria

Patient Selection Criteria
Thyroid gland diameter should be smaller than 10 cm and thyroid volume smaller than 45 ml in USG
Dominant nodule diameter in USG should be less than 50 mm
A benign disease as thyroid cyst or nodular goiter
Follicular neoplasm
Micropapillary thyroid cancer with no doubt of metastasis
Patient Exclusion Criteria
Not suitable for surgery
Not to be able to undergo general anesthesia
Previous head, neck, upper mediastinum radiation
Previous neck surgery
Thyroid volume to be >45 ml and thyroid diameter >10 cm
Dominant nodule diameter to be > 50 mm
Large goiter
Recurrent goiter
Poorly differentiated cancer
Presence of lymph node or distant metastasis
Tracheal or esophageal invasion
Recurrent laryngeal nerve palsy
Biochemical hyperthyroidism
Presence of therapeutic dental braces
Presence of oral abscess

Preoperative Preparation

Along with a rich oral flora, the natural host defense system prevents bacterial colonization and invasion of local tissues. Three intraoral incisions will create a path for the oral bacteria to be contaminated to the neck. Poor oral hygiene can contribute to the invasion of oral bacteria to tissue. Good oral and dental hygiene can prevent postoperative infections. Dental check-up and care is recommended 1 month before TOETVA operation, especially in high-risk patients with diabetic and cardiovascular disease (46). Chlorhexidine mouthwash is recommended 3 times a day preoperatively and can be continued for 5 days postoperatively (42,47).

Standard conventional thyroid surgery is in the clean wound classification. Due to the risk of contamination with the oral flora, TOETVA surgery is classified as clean-contaminated wound. Antibiotic prophylaxis including gram-positive and anaerobic bacteria is recommended in TOETVA surgery. Preoperative intravenous amoxicillin/clavulonic acid is a suitable option for prophylaxis (35,42,46). Clindamycin may be used in patients with penicillin allergy (44). Continuation of oral antibiotic therapy for 5-7 days postoperatively is recommended by some authors (42).

Surgical Team

TOETVA requires specific training. Since it is a new method nowadays, it is suggested to be performed especially in specific centers (46). The team should be experienced for thyroid surgery and laparoscopic surgery.

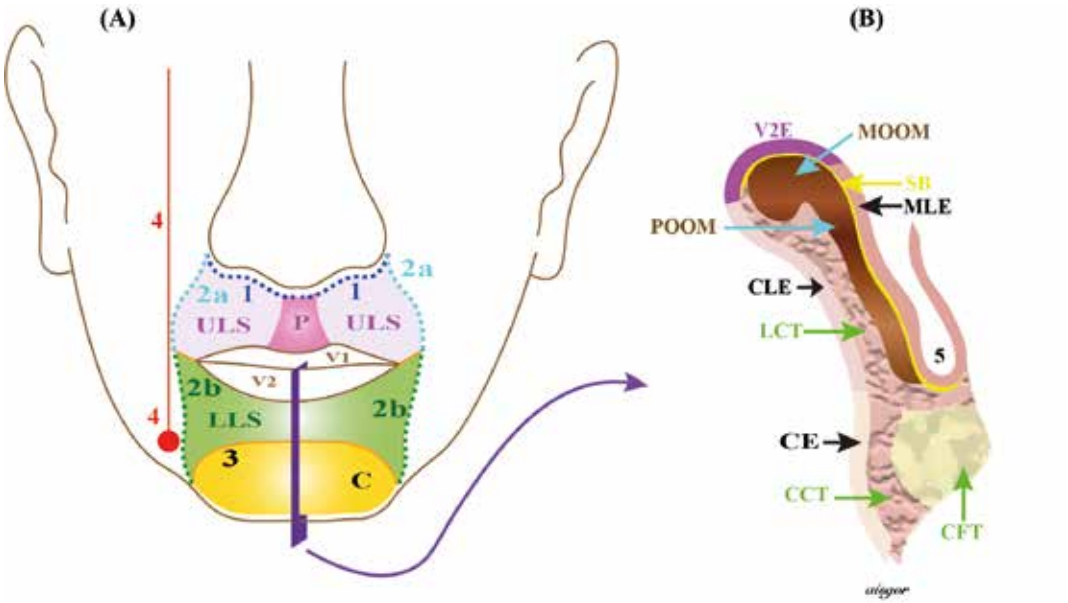

Figure-1: Topographic landmarks of the lips and the chin. **A)** 1: Nasal base, 2a: Nasolabial crease, 2b: Labiomandibular crease, 3: Mentolabial crease, 4: Mid-pupillary line and mental foramen, 5: vestibule, ULS: Upper lip subunits, P: Philtrum, LLS: Lower lip subunit, C: Chin, Upper (V1) and lower (V) vermilion. **B)** Epithelium of vermilion (V2E), lower lip (CLE) and chin (CE). Connective tissue of the lower lip (LCT), the chin (CCT). The fatty tissue of the chin (CFT). MLE: The epithelium of mucosa of lower lip, SB: Submucosa, 5: Vestibule.

ANATOMY

The most important surgical steps of the TOETVA technique are the dissections of the lower lip, midline of the chin, and midline of the neck. Some anatomical structures should be protected undamaged during this dissection. Therefore, it is important that the anatomy of this region is understanded by the surgeon using this technique. The anatomy of this region will be examined in detail, since the oral access to thyroid gland is a new route for general surgeons and endocrine surgeons.

Superficial marks: The upper and lower lip subunits, chin and location of mental foramen and signs that help determine the location of these are given in Figure-1A.

Lips

Lips; basically consists of lower and upper lower lip units and a subunit called vermilion. Vermilion is the part of the lips that is visible from outside when the mouth is closed, has a distinctive border and is pinkish in color compared to the skin. The lower and upper vermilion join at the labial commissure.

From the outside, the margins of the upper lip subunit are; nasal base cranially, nasolabial creases at both lateral sides, and the upper vermilion caudally, while the lower lip subunit margins are formed by lower vermilion cranially, labiomandibular folds at both lateral sides, and mentolabial fold, which is in the inverted "U" shape, caudally (Figure-1A). Unlike the lower limb, there is a depression so-called "philtrum," which is located in the middle of the upper lip subunit, resulting from the special organization of the orbicularis oris muscle. Thus, the upper lip consists of the upper lip subunits in both sides and the the philtrum in the middle. As mentioned above, the section which is located within the dissection area in TOETVA technique and known as the chin, is located between the labiomandibular grooves on both lateral sides, mentolabial groove cranially, and the lower anterior margin of the mandible (the mandibular mental notch and mental tubercle) caudally (Figure-1).

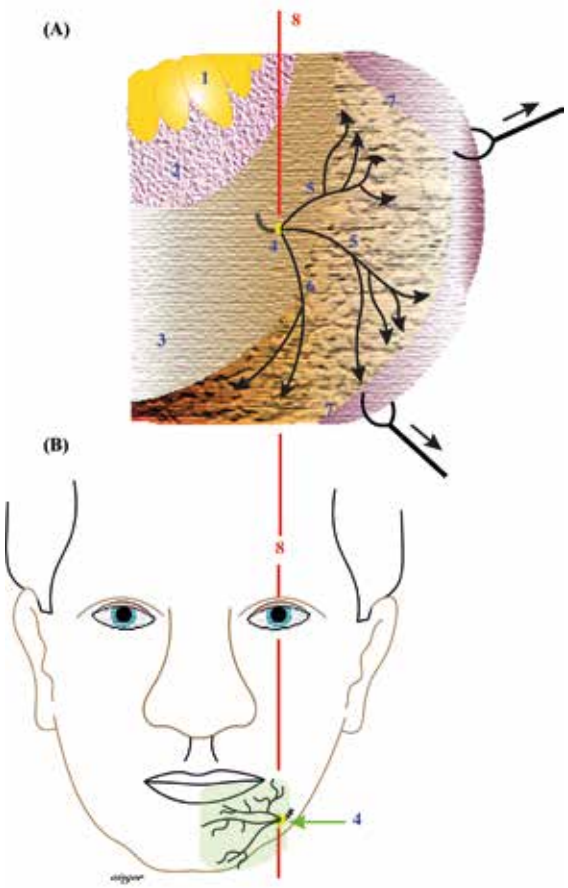

Figure-2: Mental nerve. **A)** 1: Teeth, 2: Gingiva, 3: Mandibula, 4: Mental foramen and mental nerve, 5: Upper branches of the mental nerve, 6: Lower branch of the mental nerve. 7: Vermilion, 8: Mid-pupillary line.

The lips, which can have individual appearance, play an important role in the formation of facial mimics, taking food into the mouth and speaking during the conversation, as well as giving the face an aesthetic appearance (48,49).

Mid-pupillary line and mental foramen: The longitudinal line drawn from the center of the pupil while the person is looking straight ahead in position is called the mid-pupillary line. On this line, there are three important foramens of the skull (Figure-2A). Supraorbital neurovascular bundle passes through the supraorbital foramen cranially, infraorbital neurovascular bundle through infraorbital foramen in the middle, and caudally, mental artery, mental vein and mental nerve through mental foramen, which is located in the mandibular alveolar bone. In this context, it should be kept in mind that mental foramen is mostly located at the level of the apical of second premolar tooth.

The mental nerve bearing solely sensory fibers is mostly separated from the inferior alveolar nerve at the level between the first and the second premolar teeth, making a 3-7 mm loop up and backwards, leaving the mental foramen and making three branches. The downward branch innerves the skin of the chin, and the two branches that come rise upwards innerve the lower lip skin and mucosa (Figure-2A, B). To prevent damage to this nerve, in the TOETVA technique, the mucosal port incision should be placed close to the vermilion and the dissection should not slip beyond lateral.

Histological structure: Structurally, from the surface to the deep or from the outside to the inside, a lip consists of a cutaneous lip covering the orbicularis oris muscle, vermilion and mucosal lip parts (Figure-1B). Cutaneous lip is covered with keratinized 3-5-fold squamous epithelium. The dermis consists mainly of connective tissue and includes adnexal skin structures such as sebaceous glands, hair follicles, and is firmly adhered to the orbicularis oris muscle. There is no fat tissue under the dermis. The mucosal lip is lined with non-keratinized stratified squamous epithelium, with submucosal small salivary glands and the submucosa is loosely adherent to the orbicularis oris fibers. For this reason, it may be easier to dissect the mucosa and submucosa from the underlying muscles. Vermilion, which represents the transition area between the mucosal lips and the cutaneus lips, is lined with moderately keratinized squamous epithelium. The epithelium contains "eleidin", which gives the epithelium a transparent appearance. Thus, capillary network covered with epithelium gives a pinkish color to the vermilion. Vermilion does not contain adnexal skin structures (50). Mucosal lip margin with vermilion, is just at the posterior to the closing line of the lips.

The chin is lined with keratinized stratified squamous epithelium, and the dermis has adnexal skin structures. Unlike the cutaneous lips, there is fat tissue under the dermis and mental muscle fibers attach here (Figure-1B).

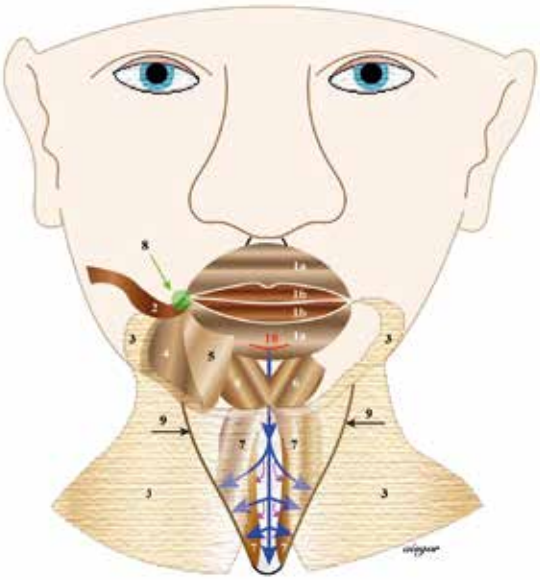

Figure-3: Muscles of the lips and chin. The orbicularis oris muscles are divided in the pars marginalis and the pars peripheralis Muscles of the lip, chin, neck and dissection plane. 1a: Upper and lower pars peripheralis (1a) and pars marginalis (1b) of orbicularis oris 2: Risorius, 3: Platisma, 4: Depressor angulis oris, 5: Levator angulis oris, 6: Mentalis, 7: Sternothyroid and sternohyoid, 8: Modiolus, 9: Anterior (medial) border of sternocleidomastoid muscle, 10: Incision site of the 10mm port. Blue arrows: Dissection plane of the midline structures (orbicularis oris, mentalis and platisma muscles after the incision of lip mucosa). Purple arrows dissection of strap muscles from thyroid.

Muscles

In this section, the lower lip and the chin muscles which may be involved in the dissection area in TOETVA technique will be presented.

Modiolus: It is a formation of mobile fibromuscular structure which is tightly attached to the dermis, by the combination of mainly levator anguli oris, depressor anguli oris, marginal part of orbicularis oris and some fibers of the other muscles (51) (Figure-3).

Orbicularis oris muscle (OOM): Although the orbicularis oris muscle (OOM) associated with many muscles around the mouth has a very complex structure and different opinions have been suggested over the years about its microscopic structure, the definition of Lightoller from the year 1925 is still widely used today (52). According to this, OOM is examined in two parts; as the marginal part which is located more anteriorly and as the peripheral part which is located more posteriorly (Figure-3). The marginal part is located in the vermilion subunit of the lips, and the peripheral part is located between the cutaneous and mucosal lips (Figure-1B, Figure-3). On both sides, the marginal part fibers starting from the modiolus course only horizontally, meeting each other in the middle and sticking to the vermilion dermis by extending to the other side (53). The peripheral part fibers starting from the modiolus are strengthened by also the other muscles in this section and course in many directions such as transverse, longitudinal and oblique, and mixed with the fibers coming from the other side and they attach to the dermis. In TOETVA technique, the port incision should be placed closest to the vermilion within the peripheral part to ensure that this muscle is minimally damaged.

The arterial blood flow of the orbicularis oris muscle is provided by inferior and superior labial branches of the facial artery, and this muscle is innervated by fibers from the facial nerve.

As mentioned before, a significant part of the lip functions are performed by this muscle.

Depressor Anguli Oris muscle: It starts from the side of the mandible and ends in the orbicularis oris muscles of the modiolus and wraps the lips partly from the side. In fact, although it is a buccal muscle, its medial part is located at the lateral side of the chin. It is innervated by the branches of the facial nerve.

Depressor Labii Inferior muscle: It begins at the mandibular oblique line between the mandibular symphysis and mental foramen; proceeds at the superomedial direction and mixes with the orbicularis oris muscle fibers and ends in the lower lip dermis beneath the depressor angulis oris muscle. It is innervated by the marginal mandibular branch of the facial nerve.

Mental muscle: It is the most deeply located muscle of the chin area. It originates from the mandibular incisive fossa under the depressor labia inferior muscle, its fibers course inferiorly and

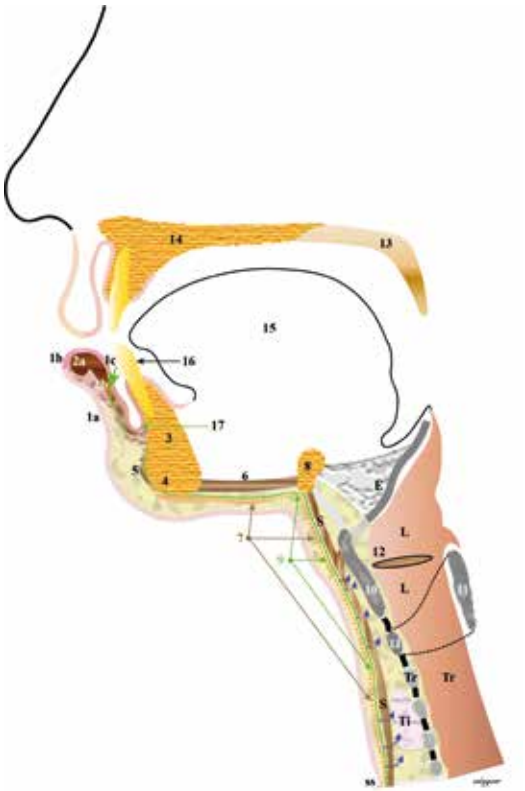

Figure-4: Lateral view of dissection plane (longitudinal section). Parts of lower lip epithelium 1a,1b,1c), Pars marginalis (2a) and pars peripheralis (2b) of orbicularis oris, 3: Mandibula, 4: Chin, 5: Mentalis muscle, 6: Base of the oral cavity, 7: platisma (there is no platisma muscle at the mid-line, it is shown with interrupted line), 8: Hyoid bone, 9: Dissection plane of midline structures (orbicularis oris, mentalis and platisma muscle after incision of lip mucosa. Thyroid (10) and cricoid (11) cartilages, 12: False and true vocal cords, 13: Soft palate, 14: Maxilla, 15: Tongue, 16: Tooth, 17: vestibule, L: larynx, Tr: Trakea, Ti: Thyroid isthmus, ss: sternal notch, E: epiglottis.

medially towards the midline, terminating with the chin in the middle, the mandibular dermis on the sides, and mixing with the muscle fibers described above. It is innervated by the marginal mandibular branch of the facial nerve. In TOETVA technique, it is the second muscle that enters the area of the dissection in the chin area other than the orbicularis oris muscle.

Platysma muscle: It originates from the fascia over the pectoral and deltoid muscles on either side, crosses the clavicles and cover the anterior and inferior parts of both posterior triangles and heads upwards. At the level of the hyoid bone, the platysma on both sides unite at the midline and course cranially and stick to the lower edge of the mandible, terminating by mixing with the risorian muscles with the orbicularis oris and depressor anguli oris (54). Therefore, the lower and medial parts of the anterior neck triangles are not covered by the platysma. Since there is a weak connective tissue between the platysma and deep fascia, the skin can move freely on deep tissues. Furthermore, since the area between the platysma and deep fascia is largely avascular, flap dissections can be easily performed without hemorrhage (55). When the midline dissection is performed with the TOETVA technique, dissection is performed subplatysmally until the dissection point of both platysma after the mental muscles are passed and the midline fascia is reached. Subplatysmal dissection is then continued until the anterior margin of the sternocleiomastoid muscle in both sides.

Strep muscles: Sternohyoid muscle originates from the back face of the sternum, extends upwards and terminates at the inferior margin of the hyoid bone. These muscles on both sides approach to each other at the midline as they extend upwards from the thyroid cartilage.

The sternothyroid muscle originates from the back of the manubrium sterni and moves upwards behind the sternotyroid muscle, attaching to the oblique line on the outer surface of the thyroid cartilage.

These two muscles cover the anterior and lateral face of the thyroid lobes and the dissection is continued between these muscles and the thyroid capsule after the midline fascias are opened in TOETVA technique (Figure-3,4).

Surgical Technique

In this study, Anuwong's method, who popularized TOETVA tecnique will be explained. TOETVA is performed under general anesthesia. Nasotracheal or orotracheal intubation can be performed. The endotracheal tube can be fixed to the right or left side of the mouth when performing orotracheal intubation. The tape used for fixing should be fixed to the upper lip, not to the lower lip. Anesthesia equipment is also

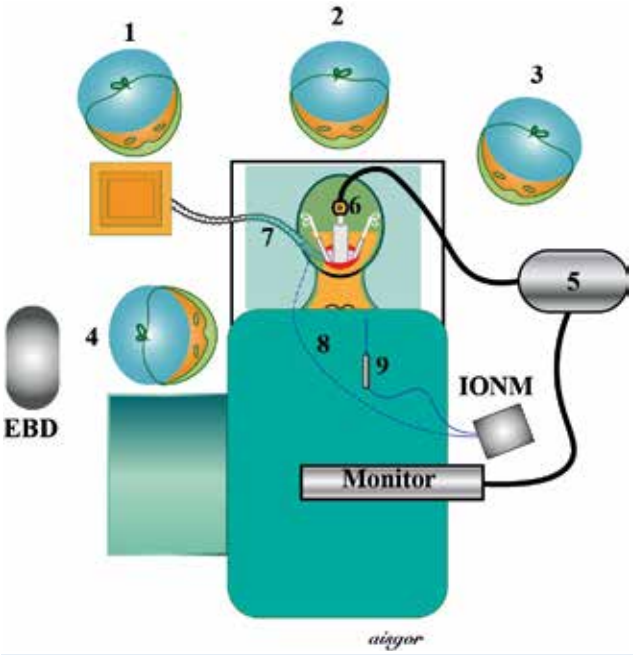

Figure-5: Operating room arrangement. 1: Anaesthetist and equipments, 2: Surgeon, 3: Assistant 4: Nurse, 5: Endoscopic unit, 6: The camera and 10 mm port, 7: Endotracheal tube and connectios, IONM: Intraoperative neural monitor, 8: IONM recording cable, 9: IONM stimulating probe.

located on the side where the tube is fixed (42). We recommend that these patients be intubated with a endotracheal tube with electrodes for intraoperative neuromonitoring (IONM).

The patient is positioned in the supine position. With a pillow placed under the shoulder, a slight extension position is given to the neck. If the neck extension is excessive, this may prevent proper expansion of the surgical field. The patient is given a Trendelenburg position of 15 degrees. The tongue is positioned to retroflexion to reveal the vestibular region. The height of the operation table is adjusted to the operating surgeon's height which she/he uses during laparoscopic surgery. The eyes and the nose are covered with a compress and fixed with a plaster. For skin disinfection, the area of surgery should be wiped with povidone iodine, covering the area from the upper lip to the both axillary region. If a drain is to be placed, the axillary region is usually preferred (46). The patient's oral cavity is irrigated with chlorhexidine or povidone iodine solution for 5 minutes (35,43).

Surgical team's settlement: The surgeon stands at the head side of the patient, the first assistant at the left of the surgeon, and the nurse stands at his right side. The laparoscopy monitor and the IONM monitor are located at the foot direction of the patient, opposite to the surgeon (42,46) (Figure-5).

Instruments required for the surgery: Veress needle for hydrodissection, Kelly forceps, one 10 mm trocar, two 5 mm trocars, 30 degrees 10 mm or 5 mm camera, long nerve probe for IONM and conventional endoscopic instruments are required. These instruments include Maryland dissector, grasper, endoscopic needle holder, L-hook coagulator, endoscopic vascular clips, energy-based device (EBD) (HARMONIC® (Ethicon Inc., Cincinnati, Ohio), LIGASURE™ (Medtronic, Minneapolis, Minnesota) and THUNDERBEAT (Olympus Corporation, Nagano, Japan), aspirator and endobag (42,46). For hydrodissection, 1 mg of 1% adrenaline is diluted with 500 cc saline (1/500 000).

Vestibular incisions: 3 incisions are made from the lower lip mucosa. These incisions should be made as high as possible to prevent mental nerve injury (46) (Figure-6). Mental nerve; is the sensory

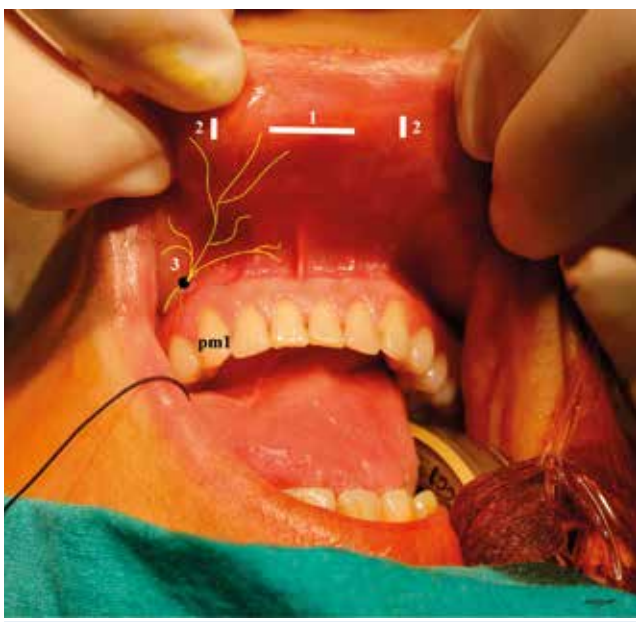

Figure-6: Oral vestibule incisions (1 and 2), 3: Location of the mental foramen and mental nerve and branches, pm1: first premolar tooth.

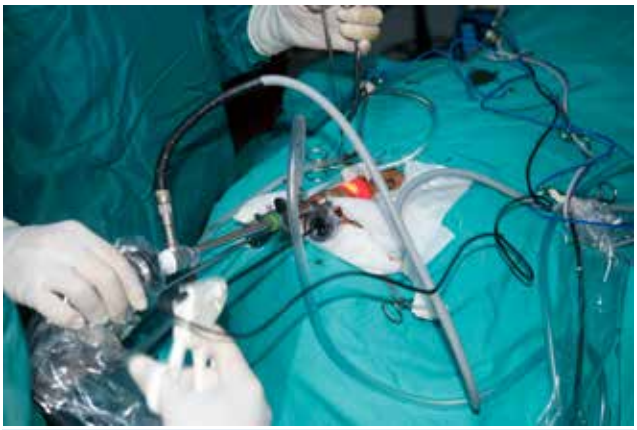

Figure-7: The entrance of the camera from the 10 mm port and the entrance of the other laparoscopic devices from 5 mm ports and the external hanging neck sutures for retraction.

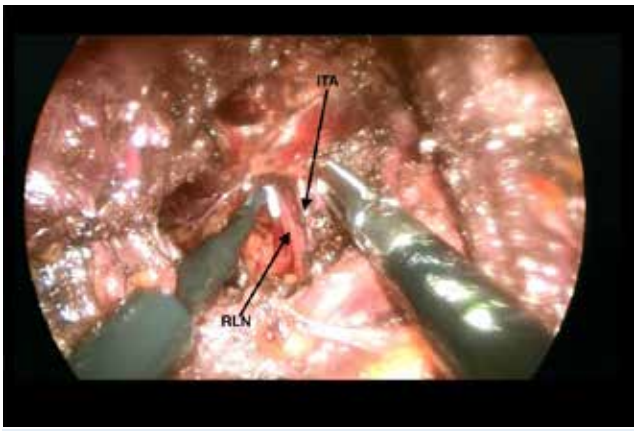

Figure-8: The view of the recurrent laryngeal nerve and the inferior thyroid artery after the left lobectomy done.

branch of the trigeminal nerve; transmitting from the mental foramen which is placed between the first and second premolar teeth, then separates into three branches, to provide the sensation of the buccal gingiva in front of the chin, lower lip and teeth (56) (Figure-2). First, a 2 cm transverse incision is made at the cranial of the inferior labial frenulum in the midline (Figure-1). From this incision, dissection is performed with monopolar electrocautery and Kelly clamp and through mental muscles, chin is reached. After reaching the tip of the chin, a physiological 1/500 000 saline of 30-70 cc is given between the platisma and the strep muscles in the study area from the tip of the chin to the neck with Veress needle for hydrodissection. The vascular tunnel probe is inserted through this incision and the subplatysmal area is dissected by blunt dissection from the sternal notch at the midline to the borders of sternocleidomastoid muscle at the right and left side. From this 10 mm incision, a blunt-ended 10 mm trocar is placed under the platysma for the camera (46,57). In order to protect the mental nerve, a 5 mm vertical incision is made in the mucosa near the vermilion margin through the lateral aspect of the canine teeth and 2 trocars of 5 mm are inserted parallel to the 10 mm trocar in the midline (57) (Figure-6). One of the probes is connected to an insufflator and the CO_2 pressure is set to 6 mmHg and the CO_2 flow rate is set to 15 L/min (58).

Subplatysmal working area (Figure-3, 4): The camera is inserted through the 10 mm port and the instruments are inserted from the 5 mm ports (Figure-7), then the fibrous connections through the subplathysmal area which are created bluntly by the vascular tunnel probe are opened by L-hook electrocautery and/or EBD to obtain the working area. For mechanical hanging, 2 to 4 suspension sutures with 2/0 silk, starting from the distal end of the 10 mm port on the midline of the neck skin, are placed, and with CO_2 pressure, a suitable working area is provided (46) (Figure-7). Workspace boundaries are the larynx at the superior, suprasternal notch at the inferior, and the frontal margins of sternocleidomastoid muscle at both sides (35). The lateral dissection margin is the same for both lobectomy and total thyroidectomy (46).

Dissection: One of the most important features of TOETVA surgery is that the operation is performed in the craniocaudal direction. Strep muscles are separated by cutting the the linea alba cervicalis with L-hook electrocautery or EBD. On the first side that will be operated, the strep muscles are dissected over the thyroid lobe. To better expose the thyroid lobe, the 2/0 silk suture placed on the skin is passed around the strep muscles and taken out again to suspend the strep muscles to the lateral (57). The middle thyroid vein is divided by EBD close to the thyroid. Isthmus is divided by EBD (35). The upper pole of the thyroid is pulled inferiorly with a grasper.

Superior thyroid arteries and veins are dissected close to the thyroid capsule and separated by EBD. During upper pole dissection, the external branch of the superior laryngeal nerve (EBSLN) can be visualized, monitored and protected (46). The released upper pole is suspended with the grasper, the upper parathyroid is exposed and carefully downwardly dissected. The thyroid lobe is pulled forward and contralateral to the anterior direction, the Berry ligament is carefully dissected, the recurrent laryngeal nerve (RLN) is exposed at its entry point to the larynx, and controlled by IONM (43). RLN is dissected in the tracheo-esophageal groove, craniocaudally downward parallel to the trachea. RLN can also be found at the crossing point with the inferior thyroid artery (35). After finding the RLN, the inferior thyroid artery and veins should be cutted at a close point from the thyroid capsule. Care must be taken not to damage the RLN while the Berry ligament is dissected. Medial retraction of the lobe allows capsular dissection (46). The Berry region can be separated by EBD if it is 2-3 mm away from the RLN with medial traction. If close, vascular clips can be applied and can be cut. After the Berry region is seperated, the dissection is continued caudally close to the capsule. The lower parathyroid is usually seen and the the lobe is released by the removal of lower pole veins.

Specimen extraction: After the lobectomy is completed, the camera is removed and the endobag, which is sutured with a purse-string sutureis placed in the workingspace through 10 mm port with the grasper. The camera is replaced and the specimen is placed in the endobag. The purse-string suture around the endobag is pulled and the opening of the endobag is closed. The camera and 10 mm port are removed. The 5 mm ports are removed. The endobag is delivered into the mouth from the incision and removed with the specimen in it. If it is difficult, it can be removed by the push and pull technique, pulling gently the endobag with the right hand while pushing the distal of the bag into the mouth (57. After the specimen is removed, the ports are placed again. Bleeding control is done by preserving RLN (Figure-8). If total thyroidectomy will be performed, the contralateral lobe is also dissected and removed according to the same principles.

Use of drain: Drain application can vary according to centers. Drain is not usually applied in lobectomy (57). However, some investigators perform routine drainage after lobectomy (43). Some investigators apply routine drainage after total thyroidectomy (35,57). There are centers also available using selective drainage during total thyroidectomy (42), and some centers do not use drains in neither total thyroidectomy nor lobectomy (40,44). If a drain will be placed, they can be placed with a 5 mm incision over the clavicle (57) or axilla (42).

Approximation of the strep muscles is recommended by closing the middle line with absorbable suture (35,40,43,46,57). There are also have centers that do not approach the strep muscles (42,44). The ports are removed and the oral mucosa may also be closed with an absorbable suture.

Central neck dissection can be performed with TOETVA technique, accompanying thyroidectomy (46).

Parathyroidectomy can also be performed with the TOETVA technique. In parathyroidectomy, thyroid lobe is mobilized and parathyroid is resected by techniques determined with preoperative imaging methods (40).

Endoscopically applied transoral vestibular approach can also be applied with robotic surgery (44). Some authors apply a fourth 8 mm bariatric port from the right axilla in addition to the vestibular ports in the robotic surgery. At the end of the surgery, they expose a drain from this port site (43).

Postoperative care: Some researchers recommend compression dressing at jaw and neck for 24 hours (35,43). Oral fluid intake is started at evening of the surgery. the patient is mobilized at 4 hours postoperatively. The patient can take a shower at the evening of the surgery (46). Oral rinse with chlorhexidine for 5-7 days is recommended. On the 7th postoperative day, toothbrushing is allowed (57). Patients may have mild emphysema and ecchymosis at the neck and swelling of the lower lip. These are treated conservatively. They usually resolve in 24-48 hours. In some patients, sensory disturbances around the chin may last 2-4

weeks. The patients are discharged according to general rules of thyroidectomy surgery (46).

Intraoperative neuromonitoring: The literature agrees that the IONM should be used as a complementary method to improve the quality and safety of endoscopic thyroidectomy (11). In endoscopic thyroidectomy, the IONM shortens the time to locate the nerve and the duration of lobectomy (59). IONM should be applied when performing TOETVA (60). In this method, the installation of the IONM, anesthesia and applications are carried out according to the standards recommended by the International IONM Study Group. Preoperative and postoperative vocal cord examination should be performed for all patients. According to the standards, pre- and post-lobectomy nervus vagus and RLS stimulation should be performed (V1, R1, R2, V2) (61,62).

Usually intermittent IONM is applied. A carotid sheath is seen lateral to the thyroid and positive signal can be obtained from the vagus by 3 mA stimulation with a probe between carotid and internal jugular vein without opening the sheath. RLS is stimulated by 1mA. EBSLN can also be monitored with IONM. Total thyroidectomy should be initiated by tumor side if it is a dominant nodule or malignant. If IONM signal is not preserved at the first side following lobectomy, the surgeon should not cross to the opposite side even the nerve is intact, and the operation should be terminated (42,43).

It has also recently been reported that continuous vagus probing sent under 10 mm port to the lodge, can perform continuous IONM by vagus dissection and vagus application (63).

DISCUSSION

Good minimally invasive thyroidectomy technique should apply the following conditions: (I) the distance to reach to the thyroid from the incision should be short in order to reduce the risk of collision of the instruments and shorten the distance of the flap dissection for less trauma, (II) the incision should be concealed in an unnoticeable area of the body for an excellent cosmetic result, (III) a good operative and anatomical image in which there are no important structures such as the carotid artery, internal jugular vein or brachial plexus near the operation site for patient safety, (IV) the oncological outcome of the specimen in good shape and borders, (V) applicable with conventional endoscopic instruments, (VI) should be a simplified technique with a short learning curve and be practicable by any trained surgeon (22).

In minimally invasive methods applied from the neck region, there is visible incision in this region. In the endoscopic methods reaching from a distance from the neck, there is a visible incision in areas other than the neck. Most of these methods are not minimally invasive methods due to large dissection areas (23). TOETVA is a true minimally invasive method that suits most of the above mentioned features: The advantages and limitations of TOETVA are summarized in Table-2 (23,45).

Table-2: Advantages and disadvantages of TOETVA (23,45).

Advantages
True cutaneous scar-free surgery
There is a wide inclusion criteria and can increase over time
Natural orifice transluminal endoscopic surgery technique
It's a true minimally invasive surgery.
Short surgical reach distance
Minimal tissue dissection to reach the surgical site
Minimizes the surgical trauma
Easy access to the subplatysmal area
Appropriate and respectful approach to anatomical planes
Midline approach: Both thyroid lobes and central region can be reached, if necessary, total thyroidectomy and/or central dissection can be performed
Can be applied both with endoscopic method conventionally and with robotic surgery
The same method can be applied in many centers
Safe postoperative period
Limitations
It is not preferred in poorly differentiated thyroid cancer, differentiated thyroid cancer with posterior extrathyroidal spread, N1b lymph node metastasis and large goitre
It turns clean surgery into clean-contaminated surgery.
Mental nerve injury
CO_2 leak
Collision of instruments
It is not suitable for 4-port transoral surgery

Table-3: Studies published by TOETVA technique (CND: Central neck dissection, L: Lobectomy, NTT: Neartotal thyroidectomy, STT: Subtotal thyroidectomy, TT: Total thyroidectomy, P: Parathyroidectomy, HDP: Hartley-Dunhill procedure)

Authors, year, reference number	n	Operations	Complications
Yang et al., 2015 (47)	41	19 L 18 STT or NTT 4 TT+CND	2 skin ecchymosis, 1 skin puncture, 1 skin burn 1 temporary RLN paralysis
Anuwong, 2016 (35)	60	34 L 26 TT or HDP	2 temporary RLN paralysis, 1 hematoma 3 transient hypoparathyroidism
Sasanakietkul et al. 2016 (39)	12*	12 P	1 temporary RLN paralysis
Dionigi et al. 2016 (42)	15	10 L 5 TT	1 transient hypoparathyroidism, 1 mild emphysema
Jitpratoom et al. 2016 (38)	46	46 TT	4 temporary RLN paralysis 10 transient hypoparathyroidism
Udelsman et al. 2016 (40)	7	2 TT 3 L 2 P	-
Anuwong et al. 2017 (57)	200	111 L 89 TT or HDP	30 (17.5%) transient hypoparathyroidism 8 (2.67%) temporary RLN paralysis 3 (1.5%) temporary mental nerve injury 7 (3.5%) subcutaneous emphysema 1 (0.5%) hematoma, 10 (5%) seroma
Park et al. 2017 (21)	18	7 L 8 L+CND 1 TT	1 transient hypocalcemia 2 seroma
Russel et al. 2017 (44)	8	6 L 2 P	1 temporary RLN paralysis
Chai et al. 2017 (64)	10	7 L 3 İ	2 temporary RLN paralysis 2 undesired parathyroidectomy
Chen et al. 2017 (63)	20	8 TT 12 L	3 transient hypoparathyroidism 1 temporary lip numbness

*Paratiroidektomi serisi

Every introduced new method brings possible new complications on the agenda. The srudies on TOETVA in the literature and the complications encountered are summarized in Table-3 (21,35,38-40,44,47,57,63,64).

With this method, the sterile neck area can become contaminated with oral bacteria. In the literature, no infection has been reported with the oral preparation with prophylactic antibiotics in thyroidectomies with vestibular approach. Mental nerve injury is of possible important complications. To avoid this, port layouts were shifted from gingivobuccal sulcus to lower lip proximity, to an upper position (35). Anuwong et al. (57) had encountered 3 transient mental nerve injuries when they applied the lateral 5 mm ports distance between the canine and the incisor teeth, although they were close to the lower lip margin. They did not encounter this complication when they changed the 5 mm port locations and applied the ports more laterally to the canine teeth.

The first endoscopic neck operation was performed with 20 mmHg and subsequently with 15 mmHg CO_2 pressure and massive subcutaneous emphysema and severe hypercapnia were encountered (65). In experimental studies in pigs, endoscopic thyroidectomies have been shown to have an upper limit CO_2 pressure of 10 mmHg (66,67). Kim et al. (68) reported that CO_2 pressure below 10 mmHg in endoscopic thyroidectomies is safe in humans. With the TOETVA technique, a suitable imaging field was achieved with 6 mmHg CO_2 pressure and a gas flow

rate of 15 L/min with minimal complication rate (58). With these values, mild subcutaneous emphysema was seen in some patients and it improved with conservative treatments. Serious complications such as pneumomediastinum and pneumothorax have not been reported (42,57).

Complications of TOETVA such as RLN paralysis and hypoparathyroidism are similar to open thyroidectomy's (35,37,38,40,42,44,57).

The most important feature in implementing a new surgical technique is patient safety. Although the use of this technique is increasing in the world, the surgical team must have experience in the thyroid surgery and laparoscopic surgery. In addition, training in an experienced center, detailed anatomy knowledge including the field of surgery, and orientation for the surgical position and appropriate case selection are important. Although the general surgery teams have knowledge about the neck anatomy, the vestibular area with the port entries is a new area of study for them. In general, thyroidectomy is performed in the caudocranial direction. The surgeon may contribute to the adaptation to TOETVA position by working in the craniocaudal direction by the head of the patient during open thyroid surgery. In the first cases, a woman who is not obese and has no short neck should be selected. In addition, unilateral thyroidectomy, especially right lobectomies should be chosen for right-handed surgeons. When a lobe with a single nodule of 2-3 cm is selected, it may be easier to see the thyroid endoscopically and dissect.

In conclusion, TOETVA is a minimally invasive thyroidectomy. Despite that it has been revealed as a safe technique in studies until today, more studies are required. The procedure should be practiced by surgeons experienced for patient safety and adequately trained in TOETVA.

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