Perspective

Transoral thyroidectomy—from experiment to clinical implementation

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Comment on: Anuwong A. Transoral Endoscopic Thyroidectomy Vestibular Approach: A Series of the First 60 Human Cases. World J Surg 2016;40:491-7.

Abstract: As worldwide first group who initiated the transoral access to the thyroid we report on our personal experience and conceptual design in dealing with this innovative approach that was part of our Natural Orifice Surgery (NOS/NOTES) project which is the next step in the evolution of minimally invasive surgery. The transoral thyroidectomy is a safe method that represents a breakthrough for the patient and a paradigm shift in the history of thyroid surgery toward a scarless and hopefully also pain-free surgery.

Keywords: Thyroidectomy; transoral

Submitted Dec 04, 2016. Accepted for publication Dec 23, 2016.
doi: 10.21037/tcr.2017.01.23
View this article at: http://dx.doi.org/10.21037/tcr.2017.01.23

Historical background

The era of thyroid surgery in Europe started in the late 19th century by pioneers like Kocher, Billroth and Halsted. At that time, patients' survival was the main target to achieve (1). After developing instruments like the ultrasound dissector (2), ligation clips and the intraoperative nerve monitoring system (3) patients' safety became the main aim in thyroid surgery making it today to a highly standardized technique and one of the safest procedures in surgery with very low morbidity.

With the advent of minimally invasive surgery in the early 1980s, endoscopic procedures have become standard in nearly all surgical fields. In thyroid surgery this effect started later since it is more difficult to find an endoscopic approach to the thyroid gland due to its location in the neck. All the requested working space has to be created, because there is no natural cavity. However, mediastinoscopy, retroperitoneoscopy and total extraperitoneal endoscopic hernioplasty have familiarized us with ways of creating the needed operative space for this purpose.

Usually, main advantages of minimally invasive procedures are seen in less pain, less bleeding, less infection risk, a faster recovery and better cosmetic results achieved by smaller scars. By now, we know that the demand on cosmetic surgery is high and increasing, because these results are obvious. On the other hand, cosmetic results have never been so important, when the standards and guidelines in endocrine surgery were developed.

The technique of minimally invasive video-assisted thyroidectomy (MIVAT) developed by Miccoli (4) is the method that has so far become widespread. Limiting factors of this method include the bothersome 20-mm cervical incision and consequently the specimen size to remove.

Because visible neck scarring can be very stigmatizing for Asian women several authors published studies describing an access outside the front neck region. Such approaches are via the chest, axillary, a combined axillary bilateral

breast, or a bilateral axillary breast approach (5,6). The development of cervical scarless thyroid surgery is a great step toward better cosmetic outcomes. However, these techniques just moved the scars from the front neck region to the axilla or the chest where they are still visible. The mentioned cervical conventional as well as the minimally invasive access to the thyroid gland do not respect the anatomically given surgical planes, e.g., cutting of skin and platysma and dividing of the strap muscles. Furthermore, all reported extra-cervical approaches do not comply with the use of the term "minimally invasive", because they are associated with an extensive dissection of the chest and neck region, thus being rather maximally invasive for the patient. All above mentioned disadvantages were our driving force in the creation of the transoral access.

Idea and rationale behind the transoral thyroidectomy

Transoral thyroid surgery was initiated worldwide for the first time in September 2007 by the New European Surgical Academy (NESA; www.nesacademy.org) as part of the NESA's Natural Orifice Surgery (NOS/NOTES) project that includes investigation of transvaginal and transoral access for various surgical procedures (7-9). Main goal of this interdisciplinary project was the introduction of a technique of thyroid resection that fulfills the following criteria: (I) respecting surgical planes and minimizing surgical trauma in thyroidectomy; (II) the access itself should be close to the thyroid gland to achieve a minimally invasive procedure; (III) achieving an optimal cosmetic result may only be obtained by performing a scarless operation; (IV) this optimal cosmetic result with scarless surgery should be achieved with minimal trauma; (V) the minimally invasive character of this approach and the optimal cosmetic result should not be reached at the expense of patient's safety. We were of the opinion that the technique that meets all of these criteria is the transoral access because the distance between the sublingual place and the thyroid gland is short, thus avoiding extensive dissection maneuvers. Furthermore, the mouth mucosa can be sutured without difficulties and repairs itself without leaving any visible scars.

Feasibility of the transoral access has been demonstrated for the first time in 2008 by our team member Kai Witzel who used a modified 20 mm oscilloscope through an intralingual incision in a porcine model (10). However, the described technique was a hybrid one because of an additional 3.5 mm cervical skin incision. For this reason, main goal of our interdisciplinary team was the development of a new totally transoral thyroidectomy technique. Since such approach has not been described before, we had first to perform preclinical investigations consisting of extensive studies of the surgical anatomy of the floor of the oral cavity and the cervical spaces on human cadavers and on living pigs (11-13). The aim of these studies was to define anatomical spaces, surgical planes and related neural and vascular structures of the frontal and lateral neck region and to create a safe and reproducible access through the floor of the oral cavity and pathway to the cervical spaces. To qualitatively determine damage to anatomically relevant structures, all specimens were dissected after performing the surgical procedure (12). We called this technique totally trans-oral video-assisted thyroidectomy (TOVAT). The acronym TOVAT describes precisely the route (transoral) and also refers to the methodology (totally video-assisted).

Although we were able to demonstrate the surgical feasibility of TOVAT as early as 2008 (11), as a result of our extensive anatomical investigations on human cadavers and living pigs (12,13), we had serious concerns about the safety of its clinical application. Main reason was the cervical region itself, which is rich in vulnerable structures. Even if the surgical approach is solely performed through a midline incision at the floor of the mouth by using the natural midline dehiscence between the genioglossus muscles and despite the fact that this area is a relatively avascular dissection plane, we were of the opinion that every inserted instrument will cause during the surgery a permanent mechanical friction with the surrounding soft tissue and muscular structures. This would lead in the best case to mild inflammatory reactions and in the worst case to hematoma formation. End stage of the reparation processes in this area would be inevitably scar formation with subsequent swallowing disorders. To our knowledge there are no data concerning the maximum diameter of an instrument that might be introduced and the specimen volume that can be removed through the floor of the mouth. Furthermore, for the placement of one or two additional trocars, besides the optic one in the midline, we also extensively studied the submandibular triangle that we divided into two compartments: the sublingual and the submandibular space (12). In the sublingual spatium, it was possible to localize the duct of the submandibular gland, the sublingual glands and the lingual nerve as well as the sublingual artery and vein. The submandibular space includes the gland, the hypoglossal nerve, the facial artery and parts of the

lingual nerve. The two spaces are partially divided by the mylohyoid muscle. The complete submandibular triangle is covered with a shield of the superficial cervical fascia, originating from the premandibular subplatysmal plane, enveloping the gland totally and running to its attachment at the posterior belly of the digastric muscle (12).

All these findings clearly demonstrated that the submandibular triangle is a no-go area for any trocar or instrument insertion and manipulation because of the risk of bleeding and harming of neural structures, e.g., paresis of the hypoglossal nerve resulting in dysgeusia. Because of these anatomic findings and the potential complications, we consequently changed our trans-oral exclusively sublingual approach to a combined bi-vestibular and sublingual access. The optical trocar was also placed in the midline sublingually, but the working trocars were moved to the vestibule of oral cavity bilaterally beneath the incisive teeth of the mandible. Through a 5-mm incision in the mucosa of the vestibule we could reach the periosteum of the mandible directly and pass under the platysma muscle and the superficial fascia to get access to the infrahyoidal working space. By entering the plane under the superficial fascia it was possible to avoid damage to the marginal branch of the facial nerve as well as damage to the facial vein. The only structure at risk in this area is the mental nerve (12). Because of all these issues and other crucial points, e.g., limited triangulation and manipulation of instruments and difficulties in visualization of the recurrent laryngeal nerve, we decided at that time not to proceed to clinical application before further preclinical investigation results were available.

Premature clinical application and drawbacks

When a new suggested surgical method departs substantially from current standard of care, scientific evaluation is a *condicio sine qua non* (14). Feasibility and safety must be secured before starting clinical application that has tremendous implications regarding expectations, surgeon responsibility, and most importantly patient safety.

Unfortunately, one member of our team who is ENT consultant did not share our view and decided to apply this technique on human beings (15,16). Because of his missing expertise in thyroid surgery, the procedures were performed on eight patients by a general surgeon from his hospital who did not participate in any of the above described preclinical trials. As expected, Wilhelm and his colleague encountered all the above predicted difficulties and concerns resulting in severe complications, such as paresthesia of the mental nerve in varying degrees in seven of eight cases (87.5%), conversion to open surgery due to specimen size in three of eight cases (37.5%), palsy of the recurrent laryngeal nerve in two of eight cases (25%), one permanent (12.5%) and local streptococci infection at the vestibular incision site necessitating incision and irrigation in one case (12.5%). These serious adverse events finally forced these authors to stop their proof-of-concept study (17,18).

A further drawback due to a hasty application of the transoral access was reported by Karakas *et al*. who presented the results of their pilot study on five patients with primary hyperparathyroidism who underwent a so-called transoral partial parathyroidectomy (TOPP) (19). The access via the sublingual access was performed more dorsally, directly in front of the trachea. In two patients, the procedure had to be converted to the conventional technique. One patient had transient recurrent laryngeal nerve palsy, while one patient suffered from a transient palsy of the right hypoglossal nerve with persisting dysgeusia. Three patients developed swallowing problems. In four patients the visual analog scale pain score was high. Also here, the authors terminated their study because of the severe complications. In contrast to our group, the preliminary tests of Karakas *et al*. from 2010 were limited to the investigation of best fitting instruments to gain access to the thyroidal region by using animal cadavers. Additionally within these initial tests, the feasibility to reach the parathyroid and thyroid glands via an entirely transoral paralingual access behind the strap muscles was investigated (20). TOPP set up the space at the dorsal side of the thyroid gland and adjacent to the trachea. The hypoglossal nerve and the lingual nerve as well as their accompanying blood vessels were anatomically related to the approach and could be injured during the procedure (21). Unfortunately, the discrediting conclusion of Karakas and his team stating that "*TOPP is nonsense with currently available devices*" shows that they did not understand the cause of their complications: the submandibular triangle is a no-go area for any trocar or instrument insertion and manipulation!

Breakthrough of the transoral thyroidectomy

We were from the beginning convinced that the transoral thyroid surgery is a promising approach because it's the only method, which is at the same time minimally invasive and cosmetically optimal. Naturally predetermined cervical layers are being separated instead of being cut and

divided. Furthermore, the mouth mucosa can be sutured directly and repairs itself without leaving any visible scars. Fortunately, there are some papers from Asia reporting on a successfully clinical application of the transoral thyroidectomy (review in 22). The most impressive report is from Angkoon Anuwong who shortly presented his initial experience with the transoral endoscopic thyroidectomy vestibular approach (TOETVA) (23). The only difference between our TOVAT and his TOETVA is the placement of the 10 mm trocar at the center of the oral vestibule while ours was introduced through the mouth floor (11). The two 5-mm trocars were inserted at the junction between the incisor and canine on both sides pointing down to the anterior neck under direct laparoscopic vision. A series of 60 procedures could be accomplished successfully. A total of 42 patients had single-thyroid nodules, and a lobectomy was performed. Twenty-two patients had multinodular goiters and two patients had Graves' disease, with total thyroidectomy or Hartley-Dunhill procedures performed. It is worthy of mention that two of these patients had papillary thyroid carcinoma where total thyroidectomy with central node dissection was done. The median operative time was 115.5 min (range, 75–300 min). The median blood loss was 30 mL (range, 8–130 mL). Two patients experienced a transient hoarseness, which was resolved within 2 months. One patient experienced a late postoperative hematoma, which was treated conservatively. No mental nerve injury or infections were found. The patients were discharged in an average of 3.6 days (range, 2–7 days) postoperatively (23). In the meantime, Angkoon performed TOETVA on more than 300 patients with similar good outcome (personal communication). The complication rate is low and similar to that post conventional thyroidectomy. The decisive step in TOETVA is the bypassing of the mouth floor, thus avoiding getting in touch with all above mentioned structures at risk.

However, main concern in the vestibular technique might be the mental nerve which is in striking distance to the two 5-mm trocars. Paresthesia of the mental nerve occurred in varying degrees in seven of eight cases (87.5%) in eMIT (16) and sensory disorders around the chin persisted in all eight patients (100%) for more than 6 months following the TOVANS (Trans-Oral Video-Assisted Neck Surgery) technique (24). Care must be taken to identify and avoid this nerve injury when making the 5-mm incisions. Maybe, placing the incision site 1 cm lateral to the buccal fold might prevent an injury to the mental nerve that emerges from the mental foramen at the first premolar teeth.

Conclusions and further visions

The concept of NOS/NOTES has changed the surgeon's perspective; natural openings of the body are used by interdisciplinary teams to reach the target region directly, thereby causing minimal tissue trauma. The aim is to reduce collateral damage and complications and to fasten recovery of the patient (7). Transoral thyroidectomy is based on entering and sliding along anatomically defined layers and planes directly, thus avoiding laceration and division of the cervical muscle layers, especially the platysma muscle.

The transoral access to the thyroid represents only the first station since this approach enables dissection and visualization of the whole mediastinum as demonstrated in our animal experiments (13). Transoral mediastinal lymph node dissection might become an alternative to the conventional mediastinoscopy for mediastinal staging and surgery.

Transoral thymectomy might replace the trans-cervical approach or the video-assisted thoracoscopic surgery or single port thymectomy. An up-to-down dissection of the esophagus until the esophago-gastro junction is surely feasible and worthy to investigate as alternative to thoracotomy and thoracoscopy with its associated high morbidity, in particular with regard to postoperative acute and chronic chest wall pain.

Beyond any doubt NOS/NOTES is the next step in the evolution of minimally invasive surgery and transoral thyroidectomy is a part of it. It represents a breakthrough for the patient and a paradigm shift in the history of thyroid surgery toward a scarless and hopefully also pain-free surgery.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned and reviewed by the Section Editor Chengzhong Cai (National Center for Toxicological Research, Food and Drug Administration, USA; Shanghai 10th People's Hospital, Tongji University, Shanghai, China).

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/tcr.2017.01.23). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all

aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Cite this article as: Benhidjeb T, Stark M, Gerntke I, Mynbaev O, Witzel K. Transoral thyroidectomy—from experiment to clinical implementation. Transl Cancer Res 2017;6(Suppl 1):S174-S178. doi: 10.21037/tcr.2017.01.23