Chapter

Transoral Videolaryngoscopic Surgery (TOVS)

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Abstract

Transoral videolaryngoscopic surgery (TOVS) for laryngopharyngeal cancer developed by Shiotani et al., uses the laparoscopic surgical system and distending laryngoscope. This method enables precise procedures and en bloc resection under a good view with videoendoscope in the structurally complex laryngopharynx. The major indications are Tis-2, and selected T3 lesions of hypopharyngeal, oropharyngeal, and supraglottic laryngeal cancer. TOVS is also considered for resectable rT1 and rT2 radiation failure cases and selected T3–4 advanced cases following neoadjuvant chemotherapy. Patients with resectable lymph node metastases are treated by neck dissection. Major contraindications are cricoarytenoid joint fixation, circumferential invasion of more than half, bilateral arytenoid invasion, and invasion to the thyroid cartilage, cricoid cartilage, hyoid bone, deep pharyngeal constrictor muscle. Oncological outcomes are good in long-term survival and larynx preservation rates with sparing radiation in half of the patients. However, advanced T stage and N3 cases showed a worse prognosis. Regarding functional outcome, swallowing function can maintain in most patients. Postoperative voice impairment can occur after wound healing. TOVS has some advantages particularly for hypopharyngeal cancer, in maneuver with smaller diameter instruments and tactile sense, and in less invasiveness without a tracheostomy, compared to other transoral surgeries.

Keywords: Transoral videolaryngoscopic surgery (TOVS), transoral surgery, hypopharyngeal cancer, swallowing function, voice impairment, sentinel node navigation surgery, conversion surgery, neoadjuvant chemotherapy

1. Introduction

Transoral videolaryngoscopic surgery (TOVS) for laryngopharyngeal cancer was developed by Shiotani and his colleagues in Japan since 2004 and the first report was published in 2010 [1–4]. This novel endoscopic transoral surgical system uses the laparoscopic surgical system and distending laryngoscope which enables en bloc resection under a good view with videoendoscope. Recently, surgical instruments used in TOVS have been modified to some extent. Good long-term survival, larynx preservation, and functional outcomes were reported [5]. In this chapter, the tips and the pearls of TOVS including detail of the surgical procedures, managements, and outcomes are described.

2. The feature of TOVS

The break out of transoral surgery for laryngopharyngeal cancer was started from transoral laser microsurgery (TLM), developed by Steiner et al. [6]. TLM is suitable for glottic lesions which are required fine and precise maneuver in a limited narrow space. Although TLM yields good oncological outcomes, the microscopic view through a rigid laryngoscope is linear and is not wide enough to observe the entire laryngopharynx. Particularly when observing the postcricoid area and inner surface of the epiglottis, it is often hidden by the blade of the laryngoscope. Multiple repositioning of the laryngoscope is also needed when the lesion is relatively large. In addition, pathological workup is difficult when piece-by-piece resection is performed.

To overcome these drawbacks, TOVS was developed. The endoscopic view under a flexible videoscope is wider than that under a microscope, and a wide working space can be achieved by using the FKWO retractor. This method enables detailed observation, precise procedures, and en bloc resection in the structurally complex laryngopharynx.

Although transoral robotic surgery (TORS) is actively performed for hypopharyngeal cancer in South Korea, tracheostomy is required because the intubation tube interferes with the arms of the robot [7]. In TOVS, a videoscope and forceps with a smaller diameter than the arms of the robot are used; hence, surgical procedure without tracheostomy is possible even in the narrow and distal spaces such as the hypopharynx. In addition, the surgeon has tactile sense through instruments. Therefore, TOVS has some advantages in maneuver and is less invasive compared to TLM and TORS, particularly for hypopharyngeal cancer.

3. Indications

The major indications for TOVS are Tis, T1, and T2 lesions of hypopharyngeal, oropharyngeal, and supraglottic laryngeal cancer. TOVS is also indicated for selected T3 lesions without deep invasion. Furthermore, TOVS is considered for small radiation failure cases (rT1 and rT2) if the lesions are resected with enough margins [8]. TOVS is also considered in advanced T3 or T4 cases after the tumor shrinks to a limited area following neoadjuvant chemotherapy (NAC). However, it is not a standard indication due to issues in the resection area, possibly leading to oncologically inadequate resection, as described in Section 11.3 (**Table 1**).

Anatomical contraindications for TOVS are cricoarytenoid joint fixation due to cancer invasion, circumferential invasion of more than half of the esophageal inlet, bilateral arytenoid invasion, and invasion to the thyroid cartilage, cricoid cartilage, hyoid bone, deep pharyngeal constrictor muscle, hard palate, and pterygoid hamulus. Oncologically sufficient resection is technically difficult, and functional preservation may not be excellent because of dysphagia and respiratory disorders due to postoperative stenosis and vocal cord movement restriction.

Patients with resectable lymph node metastases are treated by neck dissection (ND) along with TOVS on the same day or 1–2 weeks later. TOVS is generally performed in N1–N2 cases; however, although they are technically resectable, TOVS is not generally indicated in N3 cases due to poor prognosis [5]. Considering that postoperative chemoradiotherapy is needed in most N3 cases, transoral surgery has little significance due to increased invasiveness without improvement in oncological outcomes.

Although the extent of lesions is the basis of decision making for surgical indications, the final decision is made by considering the systemic condition. Preoperative swallowing function should be evaluated in cases predisposed to dysphagia, and surgical indication should be conservatively decided. Age; performance status;

Primary site	Hypopharynx, oropharynx, supraglottic cancer Tis-T2, selected T3 cases Resectable rT1–2 cases Seleted advanced T cases following NAC Contraindications Cricoarytenoid joint fixation Circumferential invasion of more than half Bilateral arytenoid invasion Invasion to the thyroid cartilage, cricoid cartilage, hyoid bone, deep pharyngeal constrictor muscle etc.
Cervical lymph node metastases	N1–2 cases Neck dissection along with TOVS
Other factors	Preoperative swallowing function Radiation history, Comorbidity (cardiorespiratory diseases, diabetes etc.) Age, Performance status, Family environments

Table 1.
Indications for TOVS.

medical history including radiation history; comorbidities such as respiratory diseases, cardiovascular diseases, and diabetes; and family environments should also be considered.

4. Devices

The FKWO retractor (**Figure 1a**, Olympus medical systems, Tokyo, Japan) with various blades is used to expose the laryngo-hypopharynx and widen the operative field of view in most cases. Weerda distending video laryngoscope (8588BV; Karl Storz, Tuttlingen, Germany) is also useful.

Endoeye flex (LTE-S190–5, Olympus Medical Systems, Tokyo, Japan; **Figure 1b**), an HD videoendoscope with a thin 5-mm diameter and an articulating tip that can bend in all directions up to 100°, is used to observe the surgical field in most cases. This endoscope is suitable to observe the structurally complex laryngopharynx with minimal device conflict during transoral surgery. In addition, it has the function of image-enhanced endoscopy (narrow-band imaging: NBI), which is useful for evaluating the extent of mucosal lesions. A rigid laryngeal endoscope (8575AV; Karl Storz), connected to a high-definition camera set (22220150–3; Karl Storz), also provides a wide and clear view.

For forceps, scissors, electrocautery electrodes, suction coagulators, and clip applicators, reusable straight devices are used. Incision and separation are performed using laparoscopic surgical instruments measuring 3 mm in diameter connected to an ordinary electrocautery unit, including separating (30721MD; Karl Storz) or scissor-type (30721 MW; Karl Storz) tip forceps and hook-type (26870UF; Karl Storz) or needle-type (26167NX; Karl Storz) scalpels. For hemostasis, a suction coagulator (8606E; Karl Storz) or hemostatic clips (8665 L and 8665R; Karl Storz) are used (**Figure 1c**).

New malleable or curved devices, including LaryngoFIT forceps and scissors (8791GHZ, 8793AZ, 8791AZ, and 8794AZ, Karl Storz, Tuttlingen, Germany), a malleable needle electrocautery electrode (KD600, Olympus medical systems, Tokyo, Japan), a fiber guide CO2 laser (AcuPulse DUO, Lumenis, Yokneam Illit, Israel), and a malleable suction coagulator (7030010, Amco, Tokyo, Japan), have been recently shown to be very helpful (**Figure 1d**). Most of these devices have a

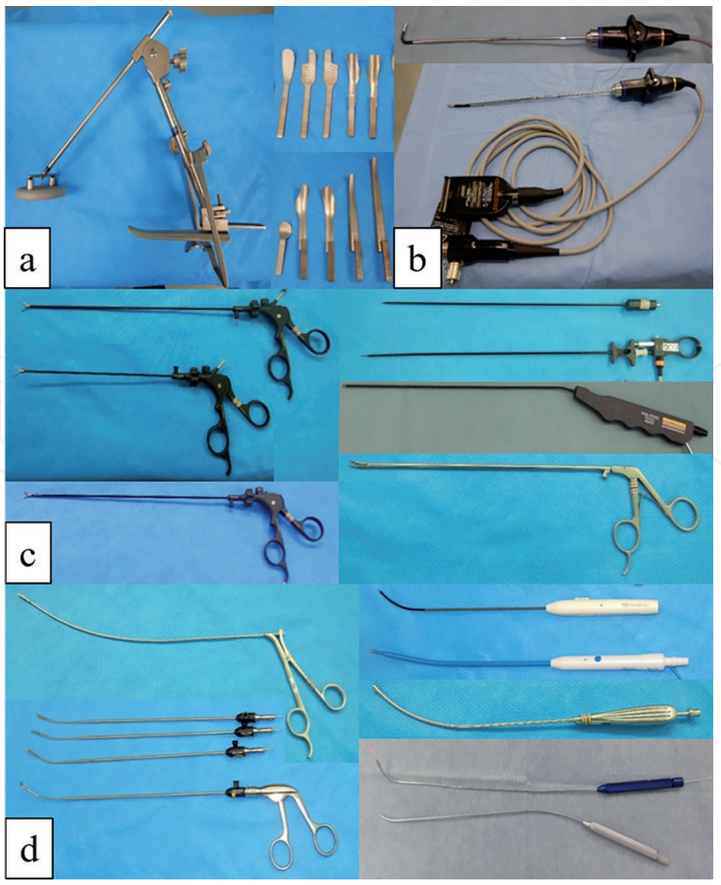

Figure 1.
Devices for TOVS. a. FKWO retractor, b. Endoeye flex, c. straight devices - forceps, scissors, electrocautery electrodes, suction coagulators, and clip applicators, d. malleable and curved devices - curved forceps, malleable forceps and scissors, malleable needle electrocautery electrode, malleable suction coagulator, curved suction, malleable and curved handpieces of fiber guide CO2 laser.

thin shaft of approximately 3 mm in diameter, except for the malleable suction coagulator, which has a thin shaft measuring 5 mm in diameter. These devices are effective for approaching from any direction in the view of the endoscope, allowing the surgeon to make parallel or perpendicular cuts along the line of sight [5].

5. Surgical procedures

5.1 Setting

TOVS is performed under general anesthesia by orotracheal intubation using a small diameter (6–7 mm) reinforced endotracheal tube. When the resection area includes the epiglottis and tongue base, nasotracheal intubation is recommended.

To expose the surgical fields, a FKWO retractor with various blades, including large blade, laryngeal blade, and tongue base blades, is the most useful for laryngopharyngeal lesions. Attaching pre-made mouthpieces to prevent tooth injury is also recommended. Although surgical field exposure is the most principal and important step to complete transoral surgery successfully, it is one of the most difficult steps that requires extensive experience and many learning curves.

Basic techniques for obtaining good surgical field exposure are as follows. For piriform sinus lesions, the laryngeal blade or tongue base blade is inserted into the glottis, vallecula of the epiglottis, or anterior end of the piriform sinus lateral of the pharyngoepiglottic fold and the aryepiglottic fold (**Figure 2a, b**). For posterior wall

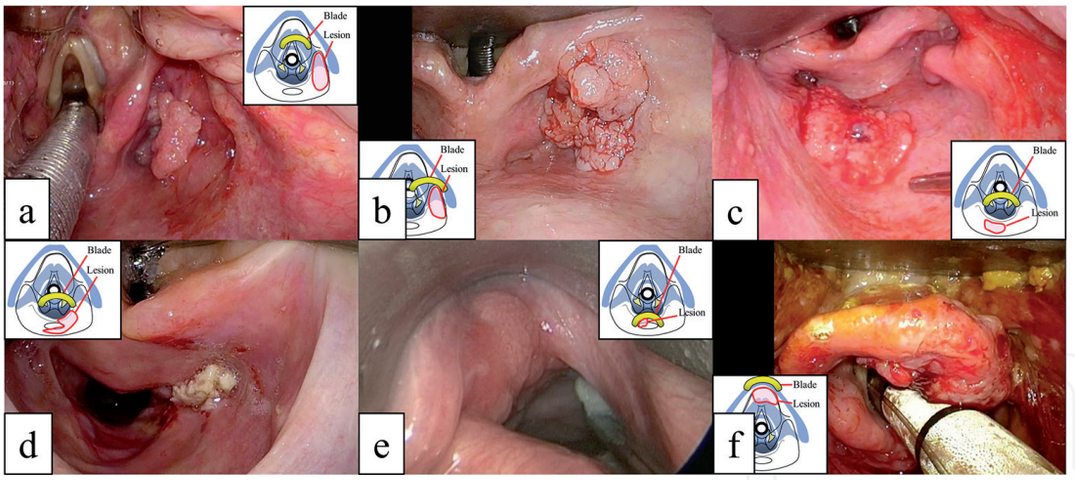

Figure 2.
Technique of surgical field exposure. a. Right piriform sinus lesion, b. right piriform sinus lesion, c. posterior wall lesion, d. Postcricoid lesion, e. esophageal inlet lesion, f. Epiglottic lesion.

lesions, the laryngeal blade is inserted into the glottis or postcricoid area (**Figure 2c**). In some of these cases, it is effective and helpful to obtain good surgical fields that the blade is inserted behind the endotracheal tube, and the tube is pushed forward (**Figure 2b, c**). For postcricoid and esophageal inlet lesions, the laryngeal blade is inserted into the glottis or postcricoid area behind the endotracheal tube, and the tube is pushed forward (**Figure 2d, e**). For epiglottic and tongue-based lesions, the tongue base blade is inserted into the tongue base (**Figure 2f**). Poor ventilation by kinking of the tracheal tube can occur due to compression by the blade, and a careful procedure is needed.

These instruments can expose most lesions; however, some patients have poor laryngopharyngeal exposure. For patents who have poor laryngopharyngeal exposure by conventional blades, novel prototypes of curved blades are currently under development (**Figure 3**). These new blades are effective to expose the distal hypopharynx to the esophageal inlet [5].

5.2 Evaluation

TOVS is performed by two head and neck surgeons. The operator manipulates instruments bimanually, and the assistant holds the videoscope to maintain an appropriate view of the surgical fields (**Figure 4a**). Occasionally, the assistant holds another pair of forceps or a suction device to support operator (**Figure 4**).

To evaluate the extent of the lesions and mark the resection area of the laryngopharynx, Endoeye flex with the function of image-enhanced endoscopy (NBI) is an ideal tool for this surgery. After meticulous washing of the laryngopharynx to remove blood and saliva with physiological saline, the lesion extent is evaluated by endoscopic vision with normal light and NBI (**Figure 4b, c**). Subsequently, iodine staining is performed to show the mucosal extent of the lesions. After 1% iodine solution is sprayed around the lesions and rinsed with physiological saline, superficial lesions can be clearly demarcated as iodine-unstained areas (**Figure 4d**). This procedure is particularly effective in identifying the boundary of lesions in hypopharyngeal cancer and oropharyngeal cancer, except that of tongue base lesions.

Palpation using forceps is also an important procedure to evaluate tumor size and deep infiltration and determine whether the lesions can be resected. In the case of lesion immovability and/or finding anatomical contraindications during the evaluation process, discontinuation of TOVS should be considered.

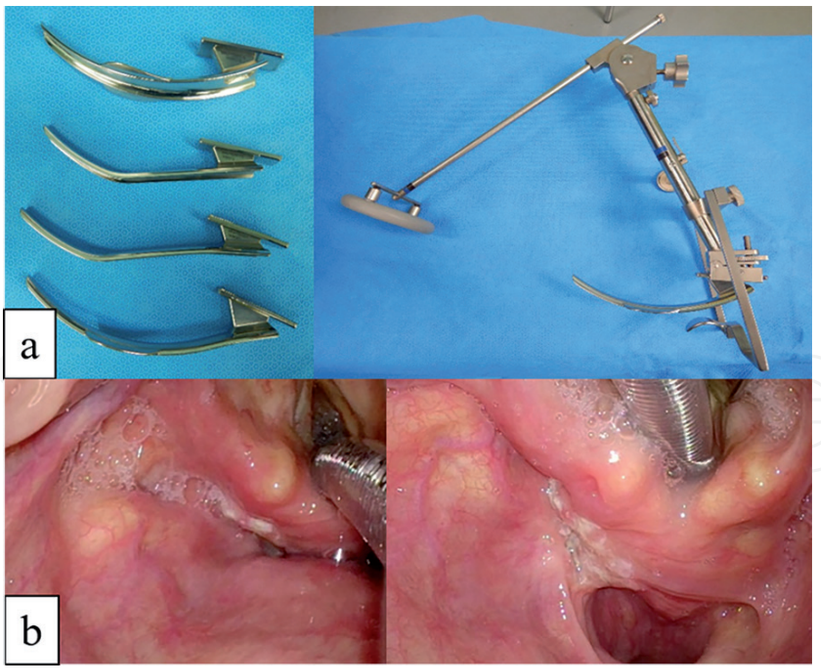

Figure 3.
Novel blades for FKWO retractor. A: Prototype of curved blades, b: Representative case (Postcricoid lesion), conventional blade (left), curved blade (right).

Thereafter, the incision line of the mucosa around the lesions is marked with a safety margin of 5–10 mm using needle-type electrocautery (**Figure 4e**). Due to cases of multiple sporadic mucosal lesions, evaluation of the entire laryngopharynx is recommended.

5.3 Resection

A soft suction tube is placed transnasally to prevent blurry vision by smoke and blood. After circumferential mucosal incision, the operator manipulates the grasping forceps to grasp and retract the edge of the lesion. Appropriate counter traction is applied to determine the appropriate incision layer and enables resection of appropriate tissue by electrocautery. In many cases, resection from the periphery to the inside enables en block resection (**Figure 4f–j**). It is important to confirm deep infiltration by palpation during the procedure. Representative cases are presented in Section 9.

Although hemostasis can be performed with a suction coagulator in most cases, multiple vessel clips should be used when thick blood vessels can be confirmed (**Figure 4k**). Bleeding from the posterior wall, the branch of the superior laryngeal artery running from the upper outside of the thyroid cartilage, or the branch of the lingual artery, is occasionally difficult to control.

Frozen section pathological analysis with the stumps of surgical margins in at least four horizontal directions and a deep margin is performed. In addition, the extracted specimen is stained with iodine to confirm the sufficiency of safety margin. Additional resection is performed based on these results when necessary.

5.4 End of surgery

In some cases, fibrin glue is sprayed to the wound to prevent bleeding (**Figure 4l**). However, it is not necessary due to the possibility of it becoming a foreign body in the airways. A nasogastric tube is inserted in cases with a high possibility of postoperative dysphagia (**Figure 4**).

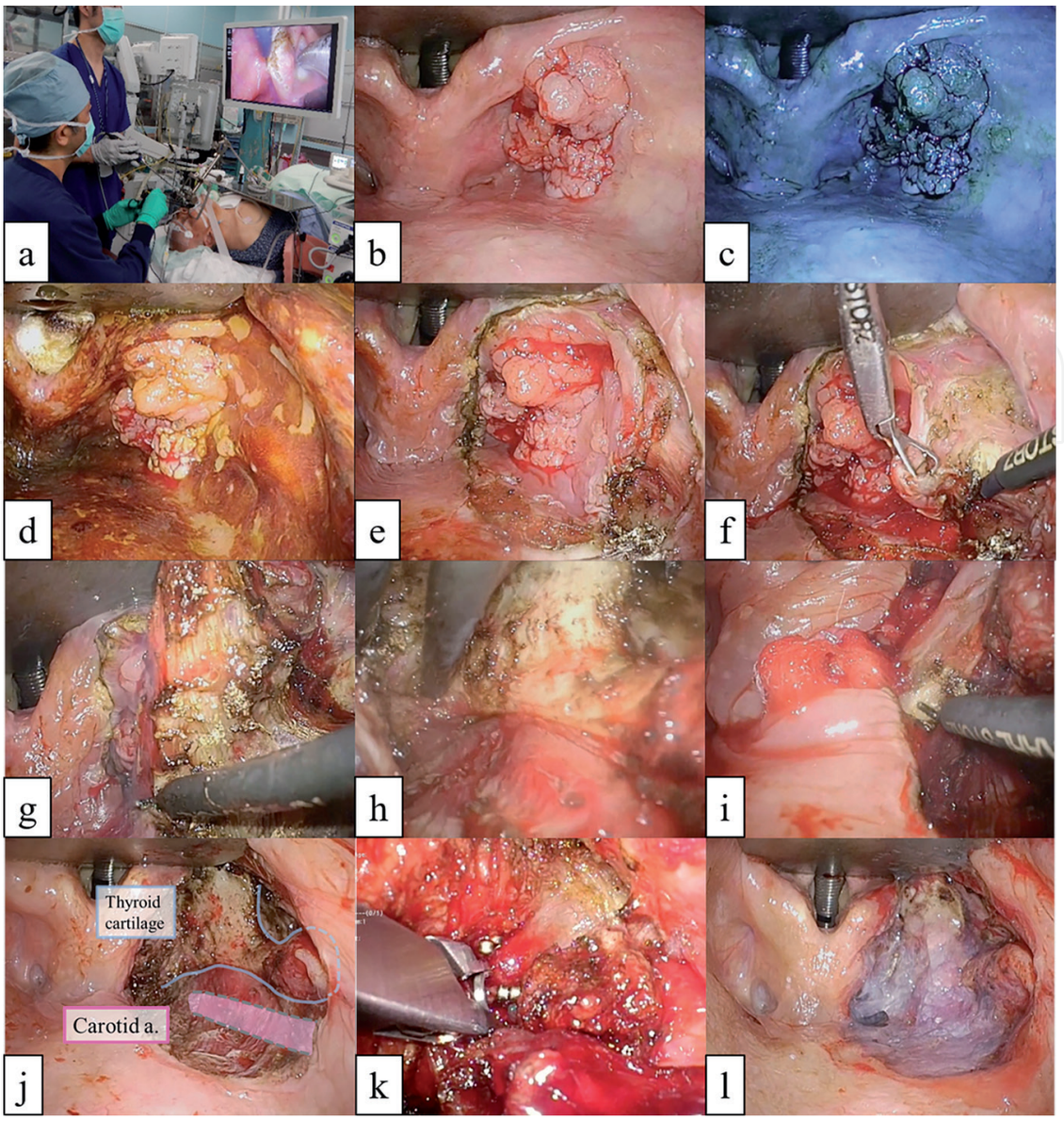

Figure 4.
Step-by-step procedure (Hypopharyngeal cancer, Rt. piriform sinus lesion). a. outside view of TOVS, b. observation with normal light, c. observation with NBI, d. observation after iodine staining, e. marking of the mucosal incision line, f. resection from the oral side, g. resection of the muscular layer, h. resection of the inner border of the thyroid cartilage, i. resection of the caudal end, j. view after resection, k. hemostasis using vessel clip, l. view after spraying of fibrin glue.

Local steroid injection (triamcinolone acetonide) is also performed to reduce the degree of postoperative scar contracture in selected non-irradiated cases. In deeply invasive tumors and previously irradiated patients, this procedure may cause wound healing complications; hence, local steroid injection should be considered in only new cases with extensive excision of the pyriform sinus, postcricoid, and/or esophageal inlet lesions [9].

TOVS can be completed without tracheostomy if no bleeding and no severe airway stenosis due to laryngopharyngeal edema is confirmed. The endotracheal tube is basically extubated immediately after surgery. In cases with suspected airway stenosis risk, extubation should be performed under preparation for immediate reintubation using a tube exchanger. Patients who have a high risk of bleeding after surgery or severe laryngopharyngeal swelling due to long surgery or neck dissection should be kept intubated or should undergo tracheostomy without hesitation.

6. Management of lymph node metastasis

For patients with node-positive disease, ND is performed after TOVS on the same day. Some patients may undergo ND separately within 1–2 weeks of TOVS.

The veins around the laryngopharynx should be preserved whenever possible to reduce postoperative laryngeal edema due to temporal insufficiency of blood flow. In N2c cases treated with bilateral NDs, severe edema of the entire laryngopharynx can occur. Therefore, careful attention should be paid to postoperative airway management and prophylactic tracheostomy should be considered.

Perforation between the wound of the TOVS and the neck can occur during ND. In such cases, postoperative infections, particularly around the carotid artery or retropharyngeal space, might be a fatal complication. Therefore, closure using a muscular flap should be performed and careful and intensive postoperative management to prevent subcutaneous emphysema and infections are necessary.

7. Anatomical tips for TOVS in hypopharyngeal cancer

The tips of the inside-out anatomy of the larynx and hypopharynx are shown in **Figure 5a**. The superior laryngeal artery and superior laryngeal nerve enter the laryngopharynx through the thyrohyoid membrane. The superior laryngeal nerve runs along the submucosal layer of the anterior wall of the pyriform sinus. The recurrent laryngeal nerve runs in a deep layer between the inferior cornu of the thyroid cartilage and the posterior cricoarytenoid muscle. The superficial branch of the recurrent laryngeal nerve usually causes anastomosis with the superficial laryngeal nerve (Galen's anastomosis).

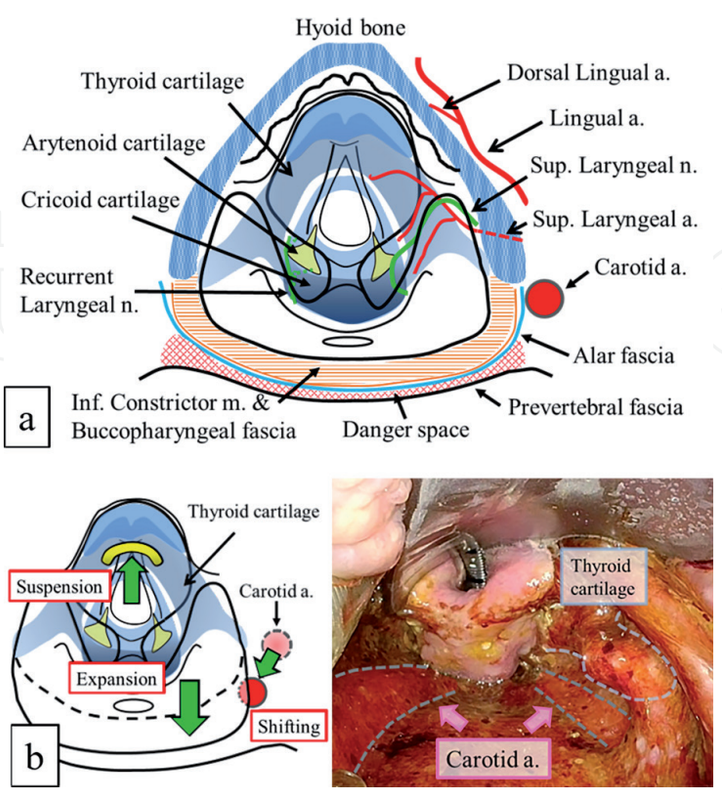

Figure 5.
Inside-out anatomy of the larynx and hypopharynx. a. Landmarks of the larynx and hypopharynx. b. Location of the carotid artery after surgical field exposure. a. Artery, n. nerve.

The carotid artery is close to the surgical field in some cases of angiectopia. The carotid artery is also close to the surgical field in cases of excessive laryngopharyngeal suspension to better expose the surgical field. The retractor opens the space between the alar of the thyroid cartilage and the prevertebral space, which causes the shift of the carotid artery from lateral to medial. As a result, the carotid artery becomes adjacent to the area between the posterior wall and the outer wall of the piriform sinus behind the alar of the thyroid cartilage (**Figure 5b**). Therefore, especially in the case that includes the pharyngeal constrictor muscle layer resection, the procedure should be performed with careful caution. Since this cannot be predicted by preoperative imaging, it is necessary to estimate the position of the carotid artery by careful observation of the arterial pulsation in the endoscopic view and the shift of the pulsating site by manual compression from the outside of the neck.

In the case of deeper infiltration in the posterior wall, the resection should also be performed with careful caution. When an excision of all layers of the pharyngeal constrictor muscle is performed, deeper damage from the buccopharyngeal fascia to the alar fascia causes perforation of the danger space in the retropharyngeal space (**Figure 5a**). This damage may cause severe postoperative complications such as cervical spondylitis and/or mediastinitis. In particular, post-irradiated cases have a high risk of developing complications due to poor wound healing and increased susceptibility to infection. Therefore, it is important to preserve the buccopharyngeal fascia and alar fascia whenever possible.

To perform better and safer transoral surgery, the surgeon should understand and familiarize themselves with the anatomical landmarks inside the laryngopharynx, check the preoperative endoscopic and imaging findings, observe surgical fields in detail under videoscopic view, and manipulate a careful procedure for each case.

8. Postoperative management

8.1 Perioperative management

Since tracheostomies are not performed in most cases, careful attention should be focused on airway management and postoperative bleeding. Laryngopharyngeal edema may worsen for a few days after surgery, although problems may not arise at the time of extubation. Routine endoscopic observation over time should be performed, and steroid administration should be considered if needed. Postoperative bleeding can occur not only immediately but also for more than 2 weeks after surgery due to crust removal during the wound healing process. Therefore, careful follow-up with a ready for emergency airway management, including tracheostomy, is necessary for more than 2 weeks after surgery.

For nutritional management, resurgence of oral intake is considered according to the extent of resection and the risk factors of dysphagia (such as age, performance status, preoperative swallowing function, and irradiation history). However, in cases with small lesions and low risk of dysphagia, oral intake can be resumed from the next day. In many cases with extensive, muscular layer resection and/or arytenoid resection, nasogastric tubal feeding is needed. Swallowing examinations such as videofluorography and/or videoendoscopy are usually performed within 1 week of surgery. Assessment for oral intake should be judged based on these results, and swallowing rehabilitation (direct or indirect training) by a speech therapist should be performed, if necessary, with being appropriate re-evaluation. In most cases, a normal diet can be resumed within 1 week to 1 month of TOVS.

In cases without any postoperative complications such as airway, bleeding, infection, and dysphagia, the patient can be discharged from the hospital. Patients with small lesions are usually discharged within 1–2 weeks after TOVS.

8.2 Long-term management

It is important to consider the possibility of pneumonia due to silent aspiration. Only a few percent of patients have long-term dysphagia [5, 10]. If long-term oral intake is difficult, gastrostomy is considered.

Epithelization of the wound healing occurs 1–2 months after TOVS in most cases. However, wound healing is very slow and takes more than 6 months in some previously irradiated cases [8]. In such cases, the risk of infection is high. Serious complications such as cervical spondylitis and mediastinitis can occur after more than 6 months after surgery. Long-term antibiotic administration is required in some cases. In addition, it is difficult to discriminate infection/inflammation from recurrence; therefore, long-term follow-up with careful observation is necessary.

Wound adhesion and scar formation due to wound healing causes fixation of the cricoarytenoid joint in some cases of extensive pyriform sinus resection. In such cases, restriction of vocal fold movement and insufficient glottic closure may occur several months after TOVS. Although there is no problem with laryngeal function immediately after surgery, dysphagia and voice disorder might worsen over a few months after TOVS. Intraoperative local steroid injection (triamcinolone acetonide) is effective; however, its indications should be limited only to new cases with extensive excision of the pyriform sinus, postcricoid, and/or esophageal inlet lesions, as described in Section 5.4 [9].

8.3 Oncological management and additional treatments

The pathological assessment of surgical margins in the resected permanent specimen is often difficult due to cauterization. Therefore, the margins are uncertain in some cases. In cases with horizontal margins, careful follow-up enables early detection, even in the case of recurrence. However, in cases with deep margins, early detection of recurrent lesions may be difficult after wound healing. In such cases, a second-look operation after 2–3 months of TOVS or postoperative irradiation should be considered.

According to pathological findings, patients might undergo postoperative radiation therapy (RT) or chemoradiation therapy (CRT). Definite positive margins, multiple lymph node metastases, extranodal extension, and perineural invasion are indications for RT or CRT.

9. Representative cases

9.1 Case 1: 64-year-old male, hypopharynx cancer, pT3N0M0

The lesion was extended from the left pyriform sinus to the posterior wall and anterior surface of the epiglottis (**Figure 6**).

9.2 Case2: 58 years-old male, hypopharyngeal cancer, rT2N0M0

Chemoradiotherapy for hypopharyngeal cancer (T3N0M0), was performed 2 years before TOVS. The recurrent lesion was located more than half of the posterior wall to the esophageal inlet (**Figure 7**).

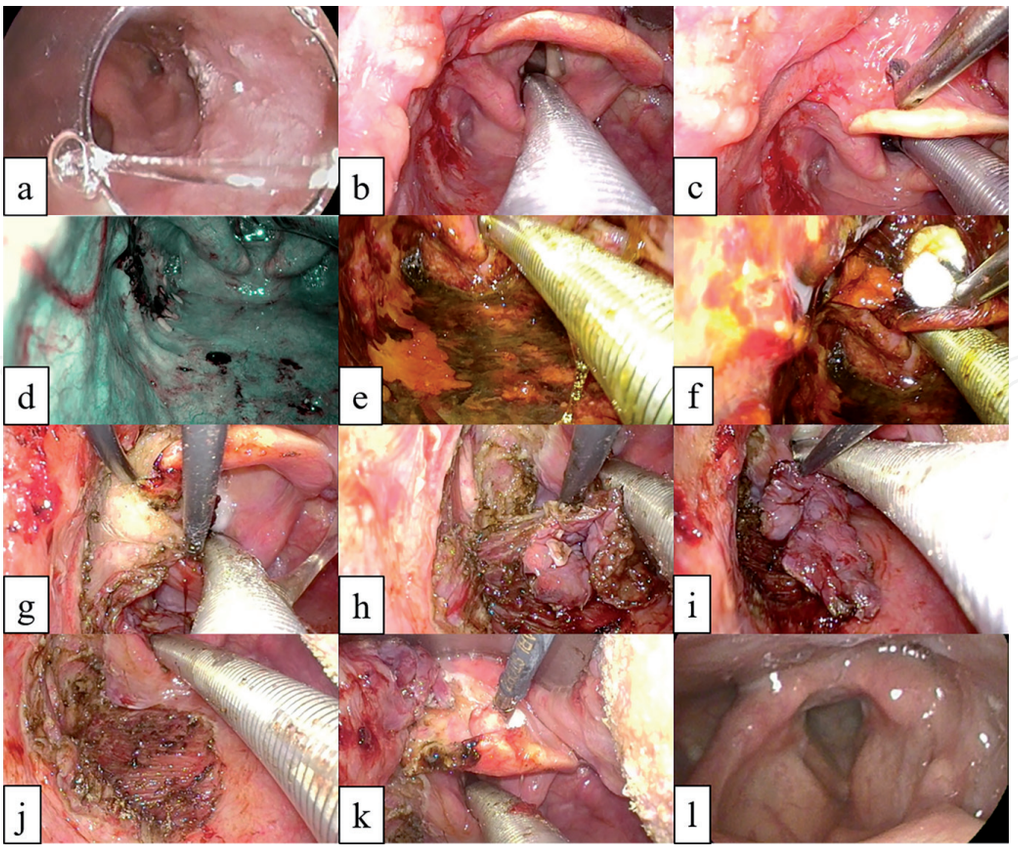

Figure 6.
Case 1. a. Pre-operative endoscopic view, b. observation with Normal light: Lesion was extended from left piriform sinus to posterior wall. c. Observation with Normal light: Lesion was extended to the left side of the anterior surface of the epiglottis. d. Observation with NBI, e. observation after iodine staining: Left piriform sinus to the posterior wall, f. observation after iodine staining: Anterior surface of epiglottis, g. resection from the left side of the anterior surface of the epiglottis to the upper side of the piriform sinus. h. Resection of the left piriform sinus to the lateral wall, i. removal of resected en block specimen, j. view after resection: Left piriform sinus to posterior wall, k. view after resection: Resected anterior surface and left edge of epiglottis, l. postoperative endoscopic view (2 months after TOVS).

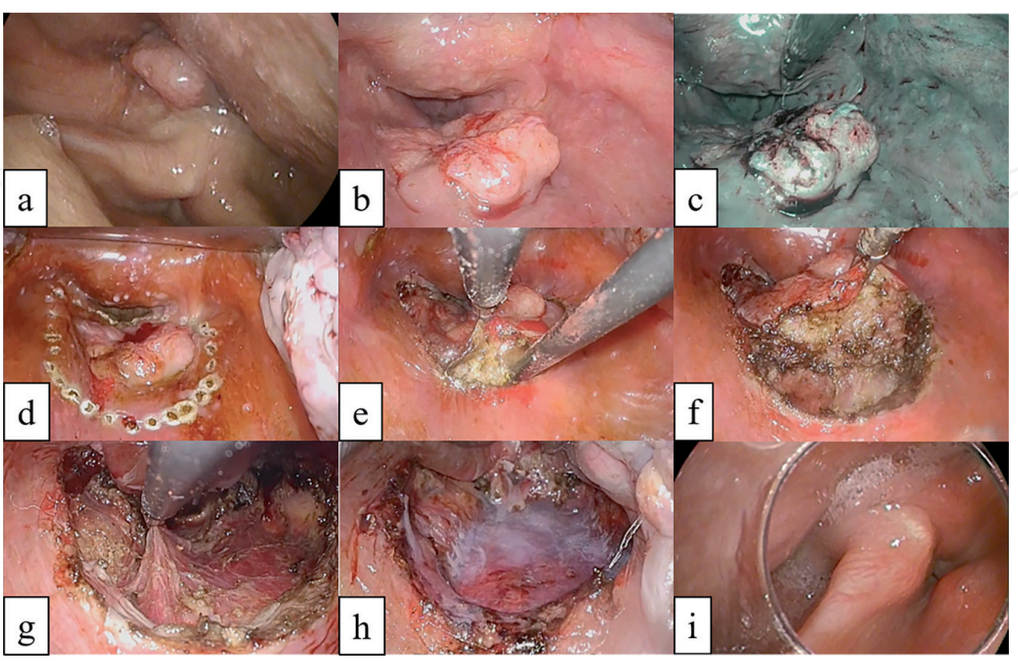

Figure 7.
Case 2. a. Pre-operative endoscopic view, b. observation with Normal light, c. observation with NBI, d. marking of the mucosal incision line, e. resection from Musclar layer of oral side, f. resection of the whole layer of pharyngeal constrictor muscle, g. view after resection: Ara fascia was preserved. h. View after spraying fibrin grue, i. postoperative endoscopic view (9 months after TOVS).

9.3 Case3: 72-year-old male, hypopharynx cancer, rT3N0M0

Chemoradiotherapy for hypopharyngeal cancer (T2NM0) was performed 10 years before TOVS. The recurrent lesion was located from the right side of postcricoid to left side posterior wall, esophageal inlet (**Figure 8**).

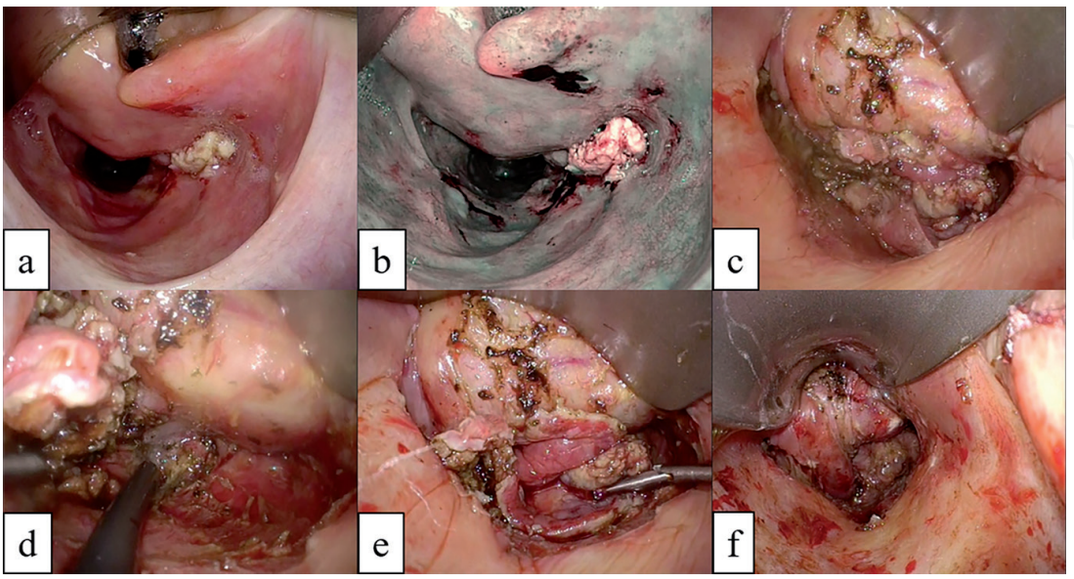

Figure 8.
Case 3. a. Observation with normal light, b. observation with NBI, c. marking of the mucosal incision line, d. resection right side of postcricoid to esophageal inlet, e. removal of resected en block specimen, f. view after resection: More than half of the posterior wall and the esophageal inlet were resected.

10. Outcomes

10.1 Oncological outcome

A recent report by Tomifuji et al. demonstrated excellent outcomes of TOVS for both new and salvage cases [5]. In 83 new hypopharyngeal cancer cases, the 2-year overall survival (OS), disease-specific survival (DSS), local control rate (LCR), laryngeal preservation rate (LPR), and disease-free survival (DFS) were 90.6%, 97.4%, 96.3%, 96.9%, and 80.40%, respectively, and the 5-year OS, DSS, LCR, LPR, and DFS were 83.2%, 94.3%, 94.7%, 94.6%, and 73.0%, respectively. In 12 salvage cases of hypopharyngeal and supraglottic cancer after RT or CRT, the 2-year OS, DSS, LCR, LPR, and DFS were 100%, 100%, 75%, 91.7%, and 75%, respectively, and the 5-year OS, DSS, LCR, LPR, and DFS were 87.5%, 87.5%, 75%, 82.5%, and 75%, respectively. Regarding T classification, advanced T stage showed worse OS and DSS outcomes than early stage. Regarding N classification, patients with N3 neck disease showed a significantly worse prognosis in terms of OS and DSS.

Among 115 cases of hypopharyngeal and supraglottic cancer, 20.8% of patients had a previous history of RT or CRT in the neck, 28.7% of patients were performed postoperative RT or CRT. As the result, 50.4% of patients could be spared RT or CRT [5].

10.2 Functional outcome

Regarding swallowing functional outcomes, most patients maintain good oral food intake. Among 115 patients more than 6 months after TOVS, the functional outcome swallowing scale (FOSS) score, which divides the swallowing function

into six stages, was 0 in 65% patients, 1 in 20% patients, 2 in 4.3% patients, 3 in 7.0% patients, and 4 in 3.5% patients (0–2, stable status; 3, unstable status requiring occasional follow-up of swallowing function; and 4–5, life-threatening status requiring tube feeding or surgical intervention). In 3.4% of patients, oral food intake could not be achieved within 6 months of surgery and required tube feeding, total pharyngolaryngectomy due to severe pharyngeal stenosis, or laryngotracheal separation surgery. Another 1.7% of patients had deteriorated swallowing function after 4.5 years and 7 years of TOVS and underwent laryngotracheal separation surgery to prevent aspiration pneumonia. Therefore, 5.2% of patients could not maintain oral intake during the long-term follow-up [5]. The risk factors associated with postoperative severe dysphagia include patient age (particularly >80 years), large resection area, arytenoid and/or pyriform sinus resection, pulmonary dysfunction, and tracheostomy [10].

Postoperative voice impairment was found in 29.1% of hypopharyngeal and supraglottic cancer cases 6–12 months after TOVS. Scar contracture after wound healing was the mechanism described in Section 8.2. Large resection area including the medial and lateral pyriform sinuses was the risk factor [11]. Surgeons should inform the patients regarding the risk of postoperative voice impairment during pre-operative counseling.

10.3 Complications

In 115 cases of hypopharyngeal and supraglottic cancer, the major complications related to TOVS were neck emphysema (7.8%, conservative observation: 100%), airway edema (6.9%, steroid treatment: 88%, tracheostomy: 12%), bleeding (2.6%, tracheostomy: 67%, reoperation: 33%), partial laryngopharyngeal necrosis due to postoperative RT and CRT (1.7%), perforation of the neck (0.86%), and laryngeal chondritis (0.86%) [5].

The proportion of patients avoiding endotracheal tube extubation immediately after surgery and maintain intubation for 1 day due to long operation time or poor oxygenation was 1.7%. Tracheostomy was performed in 9.5% of patients—in 4.3% of patients, prophylactic tracheostomy was performed; in 3.4% of patients, emergency tracheostomy was performed; and in 1.7% of patients, preoperative tracheostomy was performed due to dyspnea or difficulty of intubation. Tracheostomy could not be closed due to persistent laryngeal stenosis and persistent dysphagia in 3.4% of all patients undergoing TOVS [5].

11. Future directions

11.1 Development of devices

In the early phase of TOVS establishment, a major problem in the surgical procedure was the conflict of instruments in the narrow laryngopharyngeal cavity due to the straight shape of the endoscope and forceps. In recent years, endoscopes, forceps, CO2 lasers, and electrocautery with flexibility have been commercially available (**Figure 1d**).

The currently available endoscopes are designed for two-dimensional imaging. Therefore, TORS, which uses three-dimensional (3D) imaging, is considered superior to TOVS. However, the newly developed 3D endoscopes that can be used for TOVS will be commercially available soon. TOVS has the advantage of having tactile sense; hence, it can be a more suitable surgery for hypopharyngeal lesions using a 3D endoscope than TORS.

In addition, new curved blades for the FK-WO retractor have been developed (**Figure 3**). In a trial conducted in our department, new curved blades enabled appropriate exposure of surgical fields in the pyriform sinus apex and esophageal inlet in five cases with poor surgical field exposure using conventional blades, and surgical procedures could be accomplished in all cases. While using curved blades, the surgical maneuver is occasionally difficult with straight devices; however, malleable devices fit well [5].

With the continuous development of devices and by combining devices such as 3D endoscopes, malleable devices, and new curved blades, TOVS will be an easier procedure with a broad indication of the entire laryngopharynx and will be a more accomplished surgery with better oncological outcomes and safety.

11.2 Management of lymph node metastasis

Cervical lymph node metastasis is one of the most important prognostic factors in head and neck squamous cell carcinoma. Although many cases of transoral surgery are in the early stage with a clinically node-negative (cN0) status, the rate of positive lymph node metastasis in patients with cN0 laryngopharyngeal cancer is approximate 20–30%. Therefore, it is debatable whether neck dissection should be performed immediately in cN0 cases.

Tomifuji et al. reported the relationship between the histological parameters of resected primary lesions of TOVS and lymph node metastasis in supraglottic and hypopharyngeal cancers. Tumor depth and venous invasion were the most useful parameters for predicting lymph node metastases. They recommended that elective ND should be considered when the tumor depth is >1 mm and/or there is a presence of venous invasion. Moreover, careful observation when the tumor depth is between 0.5 and 1 mm, and, regular clinical follow-up when <0.5 mm, are recommended, respectively [12].

Another promising strategy for the management of lymph node metastasis is sentinel node navigation surgery (SNNS). It enables a personalized evaluation for neck dissection in cN0 cases individually, thereby eliminating unnecessary ND. Araki et al. reported a multicenter feasibility study of the combination of transoral surgery with SNNS for laryngopharyngeal cancer using an intraoperative injection of indocyanine green. In 22 patients with cN0 hypopharynx, oropharynx, or supraglottic cancer, the accuracy, sensitivity, and specificity of the combination strategy were 95.5%, 75%, and 100%, respectively. The 5-year DSS rate was 100%, and OS was 72.3% [13]. This combination strategy holds promise as a feasible tool for personalized and minimally invasive treatment options for both primary lesions and lymph node metastasis with favorable oncological outcomes.

11.3 Conversion surgery with neoadjuvant chemotherapy (NAC)

While the major indications for TOVS are early-stage up to T2, TOVS can be performed in selected cases with advanced lesions when NAC is effective for shrinking the lesions. Tomifuji et al. reported good results of conversion surgery with NAC. In the cases of T3 and T4 hypopharyngeal cancer treated by NAC (cisplatin +5FU or docetaxel + cisplatin +5FU) followed by TOVS, the 5-year OS, DSS, LCR, LPR, and DFS were 75.0%, 82.5%, 91.7%, 100%, and 66.7%, respectively [5].

Although this strategy of conversion surgery seems to be effective, it also has an issue. When lesions shrink by NAC, the remaining lesion may be a single mass

in some cases or multiple scattered lesions in other cases. When the resection area is limited to shrunk lesions, some of the scattered lesions outside the resection area might be missed despite the negative resection margin. The resection areas after NAC should be determined according to the initial lesions, and it is technically difficult to completely resect the entire area of the original advanced lesions. Hence, the indication of TOVS as a conversion surgery for advanced lesions should be limited to highly selected cases, and research on an appropriate and effective strategy for conversion surgery with NAC is necessary for the future.

11.4 Other than laryngopharyngeal cancer surgery

TOVS can be applied to any other surgery in addition to that for primary laryngopharyngeal cancer. Parapharyngeal and retropharyngeal metastatic lesions can be treated by TOVS in combination with a navigation system [14]. Less invasiveness surgery is needed for benign diseases in the laryngopharyngeal region compared to that for malignant diseases. The technique of TOVS has great benefits as a minimally invasive surgery for benign diseases including cysts, papilloma, benign

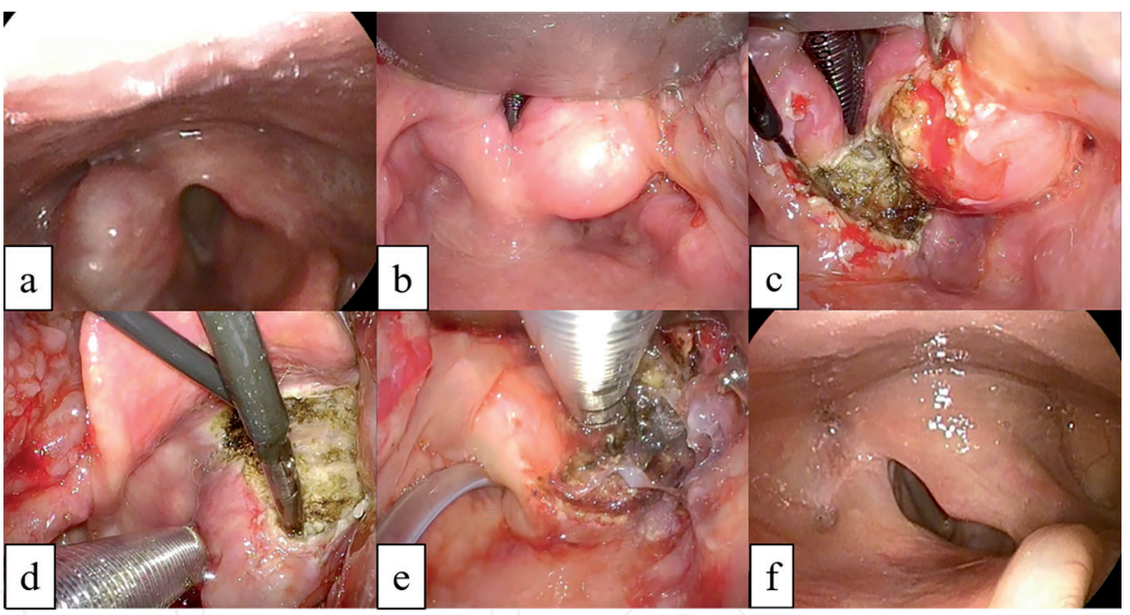

Figure 9.
56-year-old male, recurrent laryngeal pleomorphic adenoma. The orginal lesion was resected 1 year ago at another hospital. The recurrent lesion was located right arytenoid to aryepiglottic fold. a. Pre-operative endoscopic view, b. pre-operative view of surgical field, c. resection from inter arytenoid to right arytenoid, d. resection of right aryepiglottic fold, e. view after resection: Whole right arytenoid to aryepiglottic fold was resected and fibring grue is sprayed. f. Post-operative endoscopic view (9 months after TOVS).

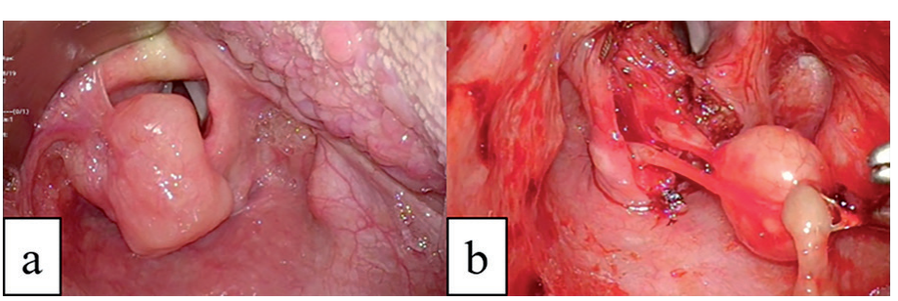

Figure 10.
19-year-old female, Neurofibromatosis type2. The lesion was located left arytenoid. a. Preoperative view of surgical field, b. resection of the lesion.

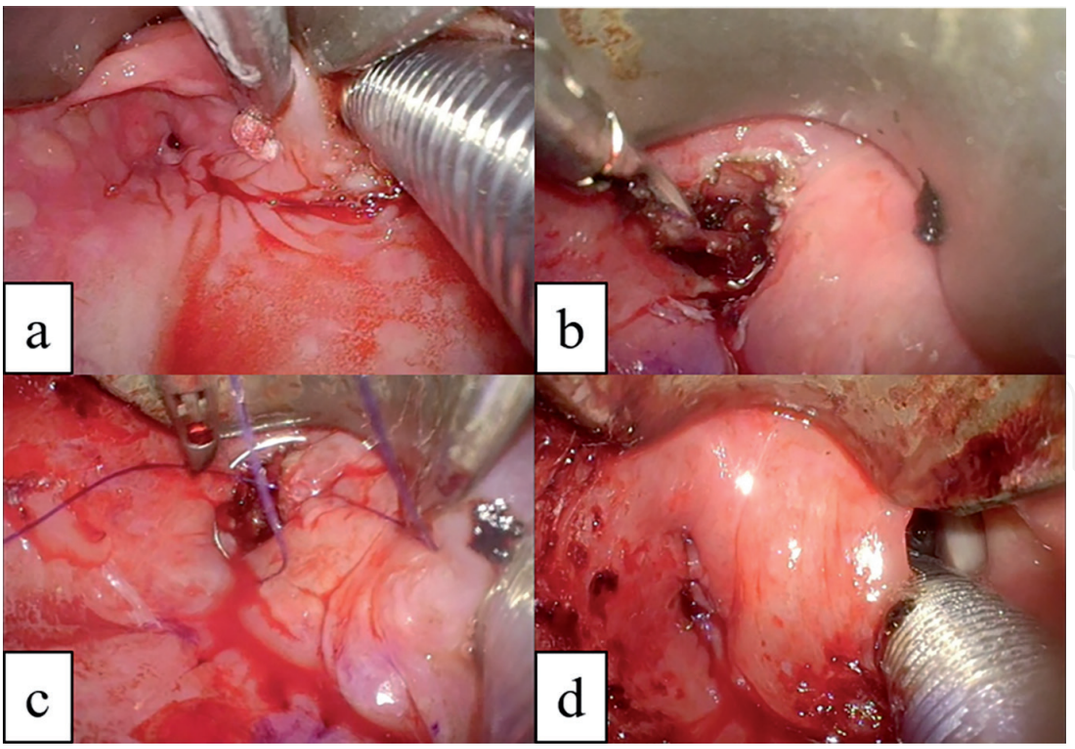

Figure 11.
30-year-old female, pyriform sinus fistula. a. Pre-operative view of surgical field, b. resection of the duct as far as possible, c. suture closure of mucosa, e. view after mucosal closure.

tumors (**Figures 9, 10**), pyriform sinus fistula [15] (**Figure 11**), foreign bodies, injection laryngoplasty for unilateral vocal cord palsy, cricopharyngeal myotomy for dysphagia, laryngopharyngeal dilatation surgery for stenosis and so on.

12. Conclusions

TOVS is a minimally invasive organ preservation surgery for laryngopharyngeal cancer with good oncological and functional outcomes. The procedure of this surgery has some advantage in maneuver and less invasiveness when compared to TLM and TORS, especially for hypopharyngeal cancer. It is expected that transoral surgery including TOVS will become increasingly popular as one of the standard treatments with the development of devices and establishing the evidence by accumulating cases.

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Conflict of interest

The authors declare no conflict of interest.

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