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TRANSORAL ROBOTIC SURGICAL (TORS) APPROACHES TO THE PARAPHARYNGEAL SPACE, HYPOPHARYNX AND LARYNX

Andrew R Larson, Andrew J Holcomb, Jeremy D Richmon

In this chapter the authors describe the use of transoral robotic surgery (TORS) for pathology of the parapharyngeal space (PPS), hypopharynx, and larynx.

TORS: Parapharyngeal Space

The PPS is a complex anatomical space extending from the skull base to the level of the hyoid. Most tumours are benign and are traditionally accessed through transcervical and/or transparotid approaches due to the complex anatomy in this area. With technological advances, however, transoral approaches have regained popularity for selected tumours as they allow surgeons to avoid neck scars, and generally present less risk to cranial nerves compared to transcervical and transparotid approaches.

TORS, with its high-fidelity 3D visualisation, magnification, lighting, and fully wristed instrumentation, has expanded the indications and popularity of the transoral approach. Herein we describe the relevant anatomy, indications, and surgical steps of the TORS approach to the PPS.

PPS Anatomy

The PPS is an anatomic space described as an inverted pyramid extending from the skull base to the hyoid bone. Its boundaries are as follows:

- Anterolaterally: medial pterygoid muscle
- Medially: buccopharyngeal fascia surrounding constrictor muscles
- Posteriorly: prevertebral fascia
- Superiorly: skull base
- Inferiorly: hyoid bone

Masses in the PPS are generally classified as either “prestyloid” or “poststyloid” according to their relationships to the stylohyoid ligament *(Figure 1)*.

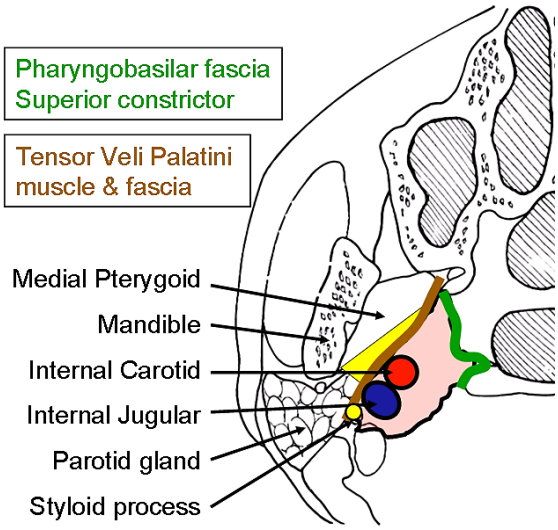

Figure 1: Axial representation of prestyloid (yellow) and poststyloid (pink) PPS

The nature of prestyloid and poststyloid masses corresponds with the anatomic contents of each space:

- Prestyloid contents
  - Fat
  - Lymph nodes
  - Deep lobe of parotid gland
- Poststyloid contents
  - Internal carotid artery
  - Internal jugular vein
  - Cranial nerves IX-XII

PPS lesions amenable to TORS include, but are not limited to:

- Benign salivary tumours (most commonly pleomorphic adenoma)
- Haemangioma/vascular malformations
- Lipoma
- Benign cyst

- Schwannoma
- Malignant salivary neoplasm
- Metastatic thyroid carcinoma

PPS Preoperative Workup

- **Patient considerations**
  - ***Trismus:*** Limits transoral access, robotic instrument docking, and may indicate pterygoid tumour infiltration
  - ***Neck extension:*** May restrict oropharynx exposure
  - ***Dentition:*** Retractors may damage decayed, loose, or capped teeth
  - ***Swallowing:*** All undergo preoperative swallow evaluation by speech-language pathologist

- **Radiographic considerations**

  - ***Tumour size*****:** Tumours up to 8cm have been removed transorally[1]
  - ***Anatomic relationship with carotid artery*****:** Medialisation of carotid artery by tumour is a contraindication to transoral approaches
  - ***Extension towards skull base:*** Tumours extending superiorly to within 1cm of the skull base are difficult to visualise and dissect transorally with current robotic technology [2]
  - ***Infiltrative borders:*** Tumours with hazy, infiltrative-appearing borders, or with ill-defined planes with the carotid artery should be accessed transcervically for wider access and proximal vessel control

Instrumentation and Setup

For detailed information and photos on room setup, exposure, and instrumentation for TORS, refer to the separate chapter "*Transoral Robotic Surgery (TORS): Setup and Basics*"

For TORS excision of PPS masses

- Intubate the patient transorally
- Administer steroids (10mg dexamethasone) intravenously to reduce airway oedema
- Use muscle relaxants to improve exposure and minimise patient movement
- Administer perioperative antibiotics to cover intraoral microbiome (we generally use piperacillin-tazobactam, or clindamycin if allergic to penicillin)
- Use a Crowe-Davis retractor to expose the oropharynx *(Figure 2)*

Figure 2: Crowe-Davis retractor (without tongue blade)

- A tongue stitch is generally not used to the retract the tongue as it does not facilitate exposure of the lateral oropharynx and causes unnecessary compression of the tongue during the surgery

Robot docking

- With adequate suspension and tumour visualisation achieved, the robot is docked transorally
- The authors use the da Vinci Si Robot (Intuitive, Sunnyvale, CA, USA)
- A Maryland dissector is used in the robot arm contralateral to the tumour

- Bovie monopolar cautery is used in the robot arm ipsilateral to the tumour
- A 0-degree robotic scope is usually sufficient for the entire transoral dissection

PPS dissection

If the mass is visible as a prominent oropharyngeal bulge

- Incise the mucosa over the most prominent prominence in the oropharyngeal wall *(Figure 3)*

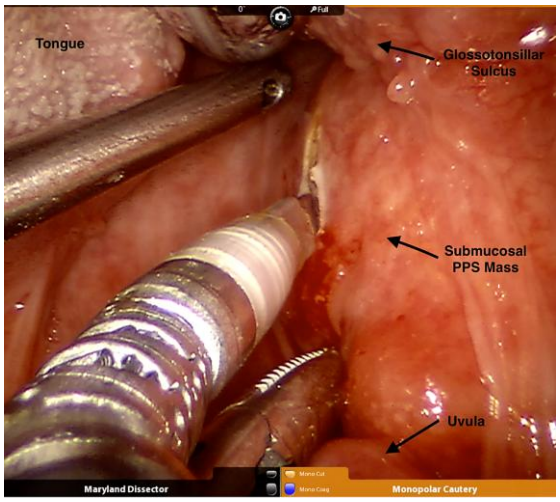

Figure 3: Right PPS mass: Initial mucosal incision made over most prominent bulge in oropharynx

- Cut through the constrictor muscle just deep to mucosa
- This should lead directly onto the mass
- It may be helpful to first remove a prominent palatine tonsil and then split the superior constrictor muscle to access the PPS

If the PPS mass is not prominent intraorally, or if tonsil tissue impedes a direct incision

- Make the initial incision in front of the palatoglossal fold, along the soft palate and towards the tongue base *(Figure 4)*

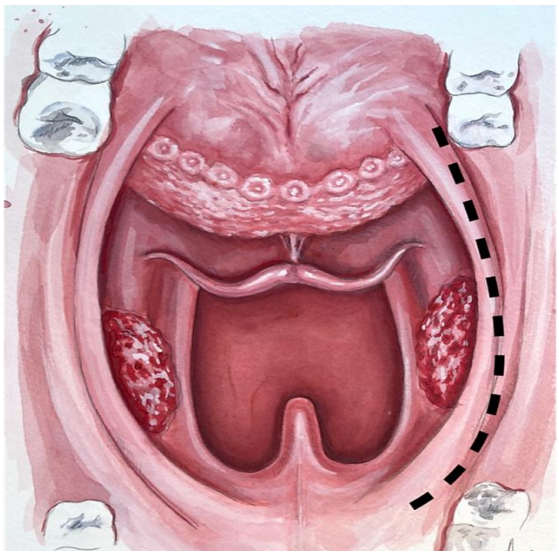

Figure 4: Incision if PPS tumour is not prominent intraorally or if tonsil impedes direct incision over the mass. Illustration by Amy Larson amylarsonlbk@gmail.com

- Dissect through or around this muscle
- This reveals the superior constrictor muscle surrounding the palatine tonsil
- Reflect a medial flap of mucosa and constrictor muscle, with/without tonsil
- This reveals the PPS and medial pterygoid muscle where the tumour is encountered *(Figure 5)*

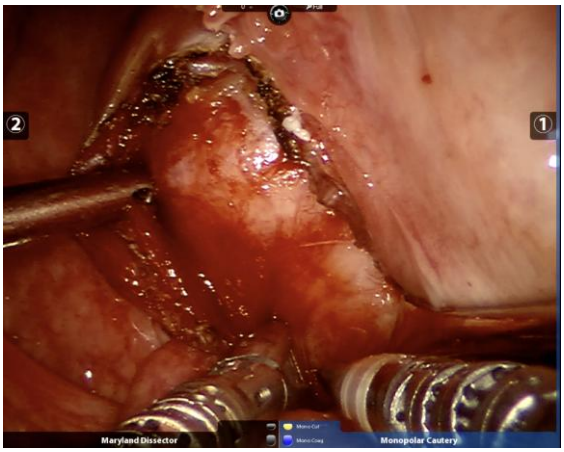

Figure 5: Robotic exposure of a large right PPS mass, following division of the pharyngeal mucosa and constrictor muscle

- Be cognizant of the ***lingual nerve*** when incising and dissecting inferiorly,

as it runs lateral to the medial pterygoid muscle and along the medial surface of the mandible *(Figure 6)*

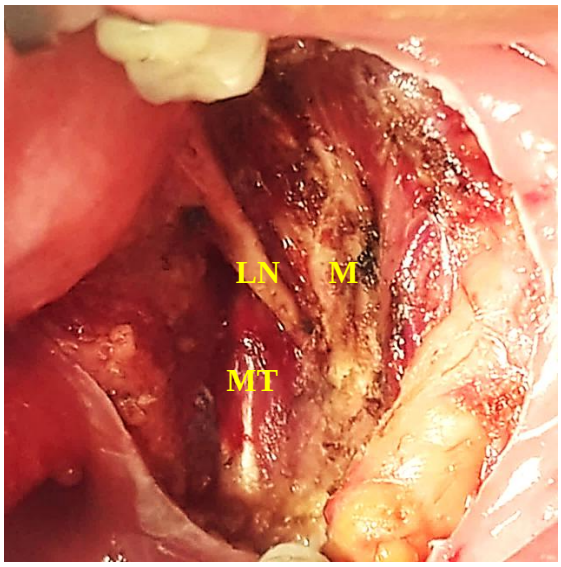

Figure 6: The lingual nerve (LN) courses lateral to the medial pterygoid muscle (MT) and medial to mandible (M)

- A silk suture can be placed in the anterior tonsillar pillar to retract the flap laterally and improve exposure of the PPS *(Figure 7)*

Figure 7: Silk suture placed in anterior tonsillar pillar to retract the flap laterally (yellow arrow)

- A red rubber catheter can also be placed transnasally to retract the soft palate. The primary surgical assistant may also use a cotton-tip applicator to provide exposure and assist with gentle blunt dissection *(Figure 8)*

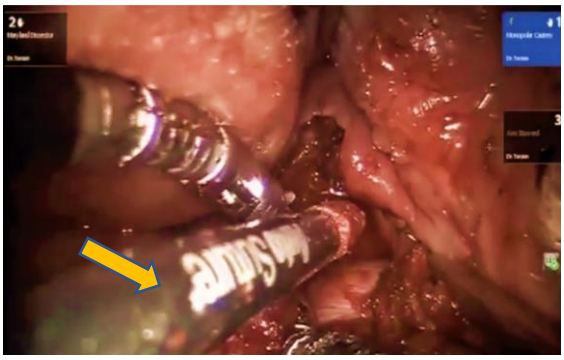

Figure 8: The surgical assistant uses a cotton tip applicator to improve exposure and for gentle blunt dissection (yellow arrow)

- If necessary, the robot may be removed intermittently during dissection to allow gentle blunt finger dissection of the tumour and to facitilate the surgeon's tactile understanding of the tumour
- Gentle external pressure on the parotid gland or under the mandible by an assistant can improve visualisation of the tumour and facilitate transoral dissection

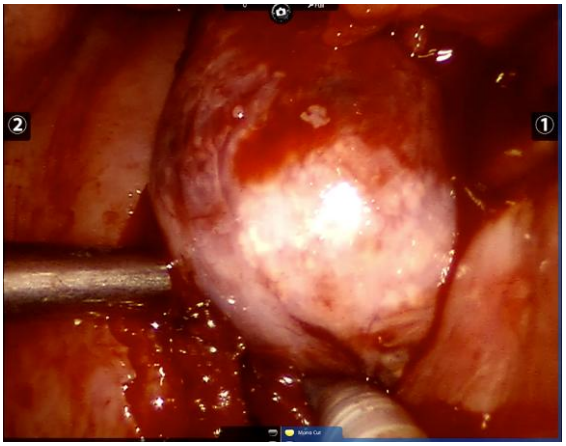

Figure 9: Robotic exposure of large right PPS mass, just prior to tumour delivery

- Given the lack of haptic feedback and use of rigid, sharp instrumentation during robotic dissection, the primary surgeon must proceed with great care to avoid capsular rupture and tumour spillage with the attendant risk of multifo-

cal recurrence in the PPS of a pleomorphic adenoma
- If spillage does occur, it should be recognised and controlled immediately by copious irrigation with sterile water and again at conclusion of the surgery
- After removal of the mass, close mucosa and muscle with a single layer of 3-0 vicryl sutures in a horizontal mattress fashion *(Figures 10, 11)*
- Leave a small opening at the most inferior point of the incision to allow egress of fluid from the wound

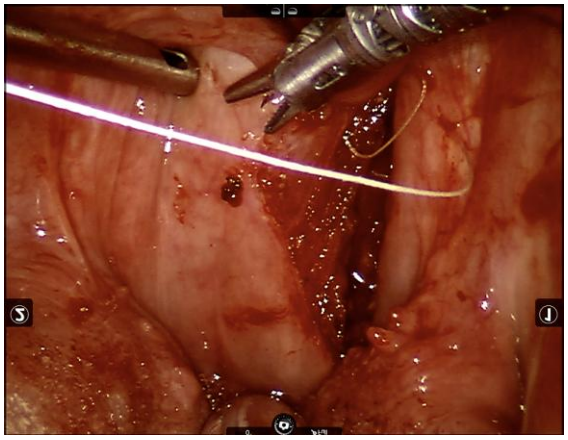

Figure 10: Robotic suturing of pharyngeal defect with 3-0 vicryl suture

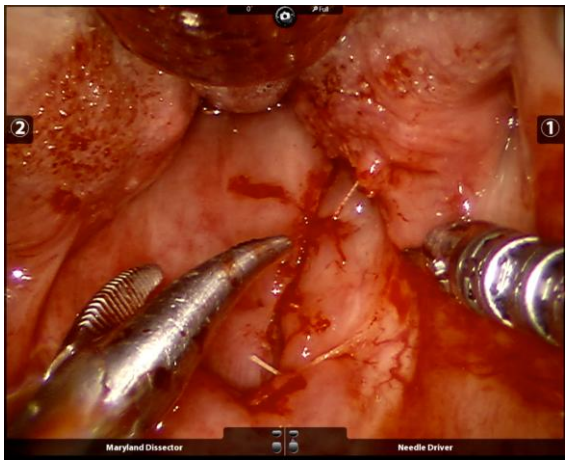

Figure 11: Final appearance of robotic closure following TORS excision of a large right PPS mass

Postoperative Care

- Commence a clear liquid diet on Day 0
- Advance to a soft diet on Day 1
- If a patient has difficulty swallowing or displays signs of aspiration, the patient is evaluated by speech-language pathology
- Continue steroids for 24hours postoperatively
- Patients are typically discharged home on oral medication on Day 1 if pain is controlled and oral intake is adequate

TORS: Larynx and Hypopharynx

Minimally invasive transoral approaches for hypopharyngeal and laryngeal cancers are safe and oncologically efficacious.[3,4] TORS, however, has several advantages over transoral laser microsurgery (TLM).

With TLM the tumour resection is performed with CO_2 laser viewed with an endoscope or microscope, often in a piecemeal fashion. The wide field of view and wristed instrumentation of TORS greatly improves 3D visualisation, spatial mobility, and haemostasis over straight line-of-site TLM through an operating laryngoscope.[5,6] Additionally, wristed instrumentation and wide exposure of TORS allows for a more traditional *en-bloc* resection with surgical margins that can be better evaluated for accurate staging and margins.

TORS hypopharyngeal and laryngeal resections include two distinct procedures: ***supraglottic laryngectomy***, and ***partial hypopharyngectomy***.

Supraglottic Laryngectomy (SL): SL encompasses a range of supraglottic resections typically performed for T1/T2 supraglottic tumours. A classical complete supraglottic laryngectomy involves resecting all supraglottic structures above the laryn-

geal ventricle with preservation of at least one cricoarytenoid complex. Yet, many supraglottic lesions are amenable to more limited supraglottic resections without compromising surgical margins. Contraindications to TORS supraglottic laryngectomy include invasion of thyroid cartilage or paraglottic space, and involvement of the glottis or anterior commissure.

Partial Hypopharyngectomy: Mobile, T1 / T2 tumours without extension to the pyriform sinus apex or direct laryngeal involvement are amenable to TORS provided that adequate tumour exposure can be obtained. Unfortunately, hypopharyngeal cancers are rarely identified at an early stage when still amenable to TORS.

Anatomy

Larynx

The larynx is a dynamic conduit between the oropharynx and the trachea, and is critical for providing an airway, airway protection, and phonation.

Anatomical boundaries of the larynx:

- Superiorly: Hyoid bone and epiglottis
- Inferiorly: Trachea
- Posteriorly: Hypopharynx

The larynx has 3 subsites:

1. *Supraglottis* extends inferiorly to the laryngeal ventricle and includes the epiglottis, aryepiglottic folds, and false vocal cords
2. *Glottis* extends from the laryngeal ventricle to 1cm below the free edge of the true vocal cord
3. *Subglottis* begins at the inferior margin of the glottis and extends to the inferior border of the cricoid cartilage

Hypopharynx

The hypopharynx is a mucosa-lined conduit between the oropharynx and cervical oesophagus. It is bound deeply by the inferior constrictor muscle and buccopharyngeal fascia.

Anatomical boundaries of hypopharynx:

- Superiorly: Hyoid bone
- Inferiorly: Cricoid / cricopharyngeus
- Posteriorly: Prevertebral fascia
- Anteriorly: Laryngeal cartilages

The hypopharynx has 3 subsites *(Figure 12):*

1. *Posterior pharyngeal wall*
2. *Postcricoid mucosa*
3. *Pyriform sinus*

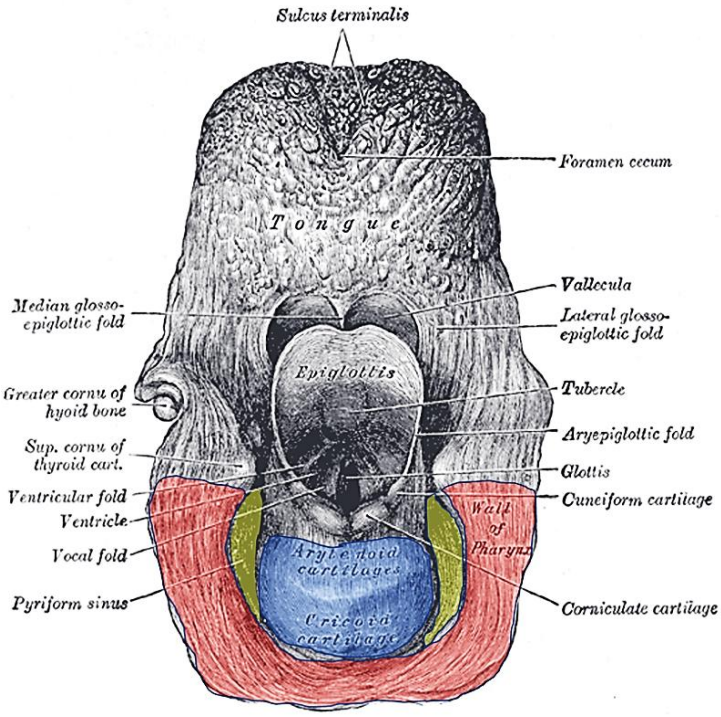

Figure 12: Hypopharynx subsites include posterior pharyngeal wall (red), postcricoid mucosa (blue), and pyriform sinus (yellow)

Preoperative Workup

- **Patient considerations**
    - ***Trismus*:** Limits transoral access and docking of robotic instruments
    - ***Neck extension*:** Limitation may re-strict hypopharyngeal exposure
    - ***Dentition:*** retractors and robotic instrument arms may damage decayed, loose, or capped teeth
    - ***Pulmonary status:*** Poor pulmonary reserve (FEV/FEV1 <50%) generally a contraindication to large supraglottic resections, as ability to tolerate subclinical aspiration is critical
    - ***Vocal cord mobility:*** Supraglottic cancer with impaired cord mobility is generally poorly suited as it indicates cricoarytenoid joint involvement
    - ***Swallowing:*** All patients undergo preoperative formal swallow evaluation by a speech-language pathologist

- **Tumour considerations**
    - ***Internal carotid artery***
        - A medialised, retropharyngeal internal carotid artery is a relative contraindication to hypopharyngectomy *(Figure 13)*
        - An ill-defined plane between tumour and carotid artery is an absolute contraindication to TORS resection
    - ***Direct laryngoscopy***
        - Direct laryngoscopy is essential to assess tumour extent and mobility before considering TORS resection *(Figure 14)*
        - It also allows the surgeon to assess transoral exposure

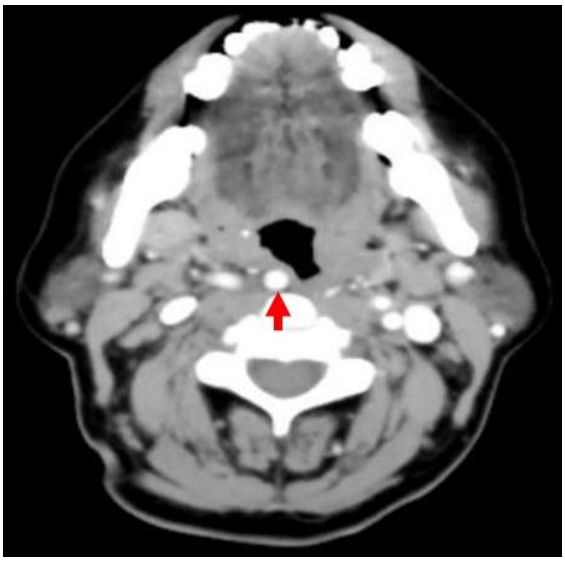

Figure 13: Retropharyngeal carotid artery

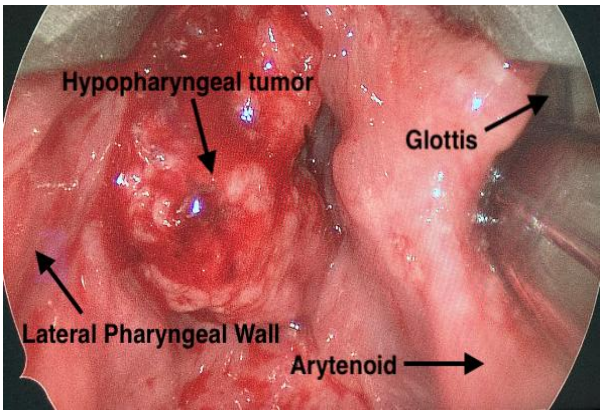

Figure 14: Direct laryngoscopy prior to TORS of mobile, squamous cell carcinoma of left lateral pyriform sinus. Direct laryngoscopy allows determination of cancer mobility and extent prior to TORS

Instrumentation and Setup

For detailed information and photos on room setup, exposure, and instrumentation for TORS, refer to the chapter ““*Transoral Robotic Surgery (TORS): Setup and Basics*”.

- Use transnasal intubation for laryngeal cases to allow posterior displacement of the endotracheal tube during laryngeal dissection

- Use transoral intubation for hypopharyngeal tumours as transnasal intubation creates difficulty with navigation around the endotracheal tube
- Administer steroids (10mg dexamethasone) intravenously to reduce airway oedema
- Use muscle relaxants to improve exposure and minimise patient movement
- Administer perioperative antibiotics to cover intraoral microbiome (we generally use piperacillin-tazobactam, or clindamycin if allergic to penicillin)
- Position the patient with neck extended as for performing direct laryngoscopy
- The authors use a Medrobotics Flex® Retractor System with a laryngeal-specific blade for exposure *(Figure 15)*

Figures 15a, b: Laryngeal and hypopharyngeal exposure with Medrobotics Flex retractor system with long laryngeal blade. Note the narrow opening of the retractor intraorally to allow instrument passage but maximize laryngeal and hypopharyngeal exposure, as well as the "direct laryngoscopy" position of the patient

- A Feyh-Kastenbauer (FK) retractor may also be used for laryngeal/hypopharyngeal exposure *(Figure 16)*

Figure 16: FK-WO retractor

- Thermoplastic splinting material e.g., Aquaplast is used to avoid damage to the teeth from dental retractors and instrument arms
- Widen the retractor enough to allow free passage of instruments
- Excessive opening of the retractor tends to shift the exposure posteriorly and away from the larynx and hypopharynx
- Placing the patient in a gentle Trendelenburg position often improves the angles at which the robotic instruments are docked
- A tongue stitch for tongue retraction is unnecessary

Robot docking

- Once adequate suspension and tumour visualisation are achieved, the robot is docked transorally
- The authors use the da Vinci Si Robot (Intuitive, Sunnyvale, CA, USA)
- The Maryland dissector is used in the robot arm contralateral to tumour
- A Bovie monopolar cautery is used in the robot arm ipsilateral to tumour

- A 30-degree robotic scope is usually sufficient for the entire transoral dissection
- Orient the robotic instrument arms as parallel as possible to the robot camera to avoid collision of instruments

Surgical dissection

- Successful tumour extirpation requires excellent exposure. Extra time devoted to ensuring adequate exposure always pays off in terms of ease and safety of the dissection as well as securing negative surgical margins
- One of the most challenging aspects of hypopharyngeal/laryngeal dissection is orienting the camera and instrument arms such that there is
  - Acceptable view of the dissection field
  - Adequate mobility of the dissection arms to complete the operation
- E.g., during hypopharyngeal dissection the camera is low (posteriorly along the posterior pharyngeal wall) while the instruments are placed high (anterior) which limits the view at the anterior part of the dissection *(Figure 17)*

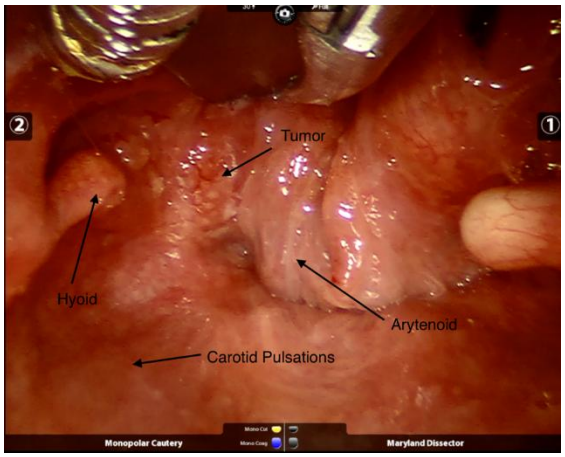

Figure 17: Exposure of cancer of left pyriform sinus with Medrobotics Flex retractor. The laryngeal retractor blade at the top of the image retracts the endotracheal tube up and out of the field of view. Important anatomic structures of the hyoid bone and arytenoid mucosa are seen. In real time, carotid pulsations are seen posterolaterally

- A 2nd assistant can manipulate the larynx externally and move the position of the hyoid and improve exposure of the tumour
- Partial epiglottectomy is described to improve laryngeal exposure when the epiglottis is prolapsed [7]. In our experience this is generally not necessary

Supraglottic Laryngectomy: Key aspects

The extent of supraglottic dissection depends on tumour location and extension. If a complete supraglottic laryngectomy is performed, key points of the dissection include:

- Initiate dissection at the vallecula/base of tongue
- Divide the pharyngoepiglottic fold(s)
- Dissect through the pre-epiglottic space to the petiole of the epiglottis
- Continue cuts along the ventricle posteriorly
- Divide the aryepiglottic fold(s) in front of the arytenoid(s) *(Figure 18)*

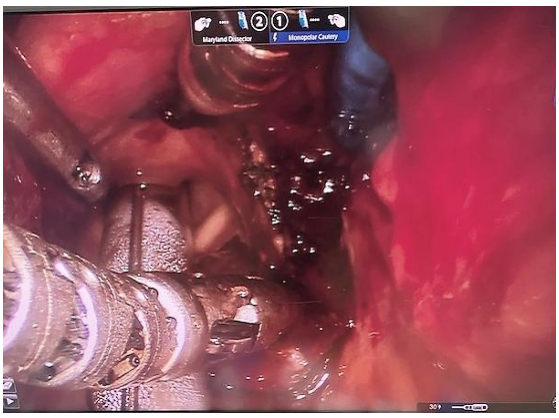

Figure 18: TORS resection of a T2 SCC of the supraglottic larynx involving the right arytenoid and aryepiglottic fold. A flexible blue suction Bovie as well as a straight-tipped rigid velvet tipped suction are used

by the surgical assistant to improve exposure and visualisation

- When dividing the pharyngoepiglottic folds, branches of the superior laryngeal vessels are often encountered and are addressed with cautery or haemostatic clips
- With large bulky laryngeal tumours, it may be necessary to bisect the tumour in the midline to facilitate manipulation and dissection

Partial Pharyngectomy: Key aspects

- Dissection is often commenced laterally where the edge of the tumour is best seen, and depth of dissection can be defined *(Figure 19)*

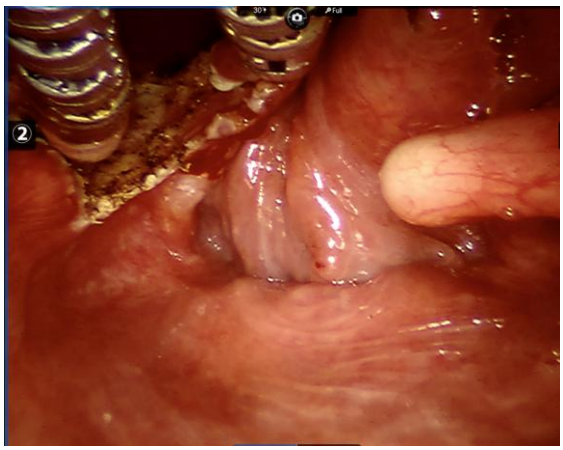

Figure 19: Lateral dissection of hypopharyngectomy for T1 SCC of lateral pyriform sinus

- Anteriorly the dissection can be continued deeply to include perichondrium of the thyroid cartilage
- Posteriorly the pharyngeal constrictor is included as the deep aspect of the dissection
- Keep in mind that the carotid artery is located deep to the posterolateral aspect of the dissection, beyond the posterior edge of the thyroid cartilage

Closure following removal of a laryngeal or hypopharyngeal tumour

- The authors coat the wound with fibrin-based sealant (Vistaseal™, Johnson & Johnson, New Brunswick, NJ, USA) after haemostasis has been achieved with monopolar cautery
- Mucosal closure is generally not required *(Figure 20)*

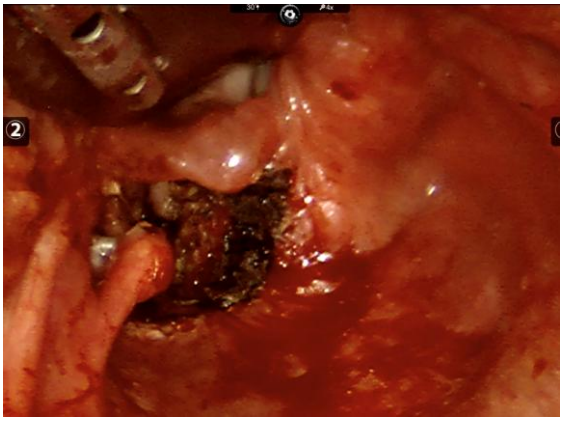

Figure 20: Resultant defect of left pyriform sinus, pharyngeal wall, and postcricoid mucosa following hypopharyngectomy

Postoperative Care

- The patient is assessed by speech and language pathology on Day 1 to assess swallowing function
- Oral feeding is initiated on Day 1 in accordance with the therapist's recommendations
- A feeding tube is only placed if a patient fails a swallow study postoperatively
- With adequate oral intake and adequate pain control, patients are discharged home as early as Day 1 and are continued on a 10-day oral prednisone taper

References

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geal space tumours. *Eur Arch Otorhinolaryngol.* 2013;271(3):575-82
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7. Virgilio AD, Park YM, Kim WS, Baek SJ, Kim S-H. How to optimize laryngeal and hypopharyngeal exposure in transoral robotic surgery. *Auris Nasus Larynx*. 2013;40(3):312-9

Additional Open Access Resources

Transoral Robotic Surgery (TORS) - Setup and Basics:
https://vula.uct.ac.za/access/content/group/ba5fb1bd-be95-48e5-81be-586fbaeba29d/Transoral%20Robotic%20Surgery%20_TORS_%20-%20Setup%20and%20Basics.pdf

Transoral Robotic Oropharyngectomy (TORS) surgical technique for cancers of the tonsil and base of tongue:
https://vula.uct.ac.za/access/content/group/ba5fb1bd-be95-48e5-81be-586fbaeba29d/Transoral%20Robotic%20Oropharyngectomy%20_TORS_%20surgical%20technique%20for%20cancers%20of%20the%20tonsil%20and%20base%20of%20tongue.pdf

Transoral Robotic Thyroidectomy (TORT) and Robotic Facelift Thyroidectomy (RFT):
https://vula.uct.ac.za/access/content/group/ba5fb1bd-be95-48e5-81be-586fbaeba29d/Transoral%20Robotic%20Thyroidectomy%20_TORT_%20and%20Robotic%20Facelift%20Thyroidectomy%20_RFT_.pdf

Detailed video of TORS dissection of a hypopharyngeal tumour by authors on the *American Head and Neck Society* website:
https://www.youtube.com/watch?v=ATIvysOdzR0

Transoral CO_2 laser microsurgery (TLM) for cancer, pharyngeal pouch, paralysed vocal cord, tracheal stenosis and papillomatosis, laryngogocele of the upper aerodigestive tract:
https://vula.uct.ac.za/access/content/group/ba5fb1bd-be95-48e5-81be-586fbaeba29d/CO2%20laser%20transoral%20microsurgery%20_TLM_.pdf

Supraglottic laryngectomy:
https://vula.uct.ac.za/access/content/group/ba5fb1bd-be95-48e5-81be-586fbaeba29d/Supraglottic%20laryngectomy.pdf

Access to parapharyngeal space:
https://vula.uct.ac.za/access/content/group/ba5fb1bd-be95-48e5-81be-586fbaeba29d/Access%20to%20parapharyngeal%20space-1.pdf

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Authors

Charles D Meyer MD
Department of Otolaryngology - Head and Neck Surgery
Naval Medical Center Portsmouth
VA, USA
chardmeyer@gmail.com

Andrew R Larson MD
Head and Neck Surgery/Microvascular Reconstruction
Lahey Hospital and Medical Center
Assistant Professor
Boston University School of Medicine
andrewroch7@gmail.com

Jeremy D Richmon MD
Ass Professor of Otolaryngology Head & Neck Surgery
Massachusetts Eye and Ear
Harvard University
Boston, MA, USA
jeremy_richmon@meei.harvard.edu

Andrew J Holcomb, MD
Head and Neck Surgeon
Estabrook Cancer Center
Methodist Hospital, Nebraska
Assistant Professor
Creighton University Department of Surgery
andrewjholcomb@gmail.com

Editor

Johan Fagan MBChB, FCS (ORL), MMed
Emeritus Professor and Past Chair
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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