Minimally Invasive Surgery for Resection of Parapharyngeal Space Tumors

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Abstract

Background Surgical removal of parapharyngeal space tumors (PPST) poses challenges due to the complex anatomy of the region. PPSTs are routinely resected by a transcervical approach using blind finger dissection. Large PPSTs or those located high at the skull base, often require transmandibular or infratemporal fossa approaches, associated with considerable morbidity.

Objective Here, we describe an approach for PPST removal that comprises transcervical endoscopic, with or without transoral robotic technique.

Materials and Methods We retrospectively studied the demographic, clinical, surgical, and outcome data of 11 consecutive patients who underwent PPST excision between June 2013 and July 2017 at our center. Patients either underwent a transcervical endoscopic procedure ($n = 4$), a transoral robotic procedure ($n = 2$) or a combination of the two procedures ($n = 5$).

Results Complete tumor excision was achieved in all cases, with no intra-, peri-, or postoperative complications. Final histopathologic findings demonstrated pleomorphic adenoma for seven patients, cavernous hemangioma for one patient, and malignant tumors for three patients. The average tumor size was $44.22 \pm 31.9 \text{ cm}^3$ (range: 7.5–111 cm^3). At follow-up (range: 3–42 months), there was no evidence of recurrence.

Conclusions The approach described provides improved visualization and safe vascular control with minimum tumor stress, preventing the need for blind finger dissection, and allowing complete tumor removal while minimizing tumor spillage, nerve injury, and blood loss, maintaining excellent cosmetic and functional results. This approach could be utilized for the removal of large benign PPST, or small PPST located high.

Keywords

- ▶ parapharyngeal space
- ▶ parapharyngeal space tumor
- ▶ minimally invasive
- ▶ transoral robotic surgery
- ▶ da Vinci robot system

Introduction

The parapharyngeal space (PPS) is a potential space shaped like an inverted pyramid, located lateral to the upper pharynx and medial to the mandible, extending from the skull base superiorly to the hyoid bone inferiorly. Its location poses challenges during surgical exposure. Parapharyngeal space tumors (PPSTs) are usually benign, originating from the salivary gland (pleomorphic adenoma), neuronal tissue (schwannomas,

paragangliomas), or adipose tissue.¹ The main indications for surgical excision of these tumors include relief of symptoms caused by mass effect, prevention of imminent morbidity, and avoidance of malignant transformation in the case of pleomorphic adenoma. PPSTs are routinely resected by a transcervical approach using careful dissection along the course of the pharynx.² This approach is limited in its ability to expose the superior aspect of the PPS, such that the upper portion of the dissection might have to be performed blindly. This increases

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the risk of tumor spillage and recurrence rate, cranial nerve injury, and bleeding. Thus, very large PPST, or those that are located high at the skull base, often require more invasive, combined approaches, which may include transmandibular (lip-splitting incision, mandibulotomy), transparotid or infratemporal fossa approaches. Those approaches allow wide exposure of the lesion but involve considerable morbidity. Recently, minimally invasive approaches to the PPS has been described.^{3,4} Several recent reports describe the clinical feasibility and safety of transoral robotic technique for resection of PPST.^{3,5-7} Transoral robotic surgery (TORS) provides excellent three-dimensional visualization, instrument access, and accurate dissection in tenuous areas, such as over the internal carotid artery, allowing successful and safe PPS and infratemporal fossa surgical resections.⁶ TORS has technical advantages, translating the surgeon's hand to scale down movements of the robotic arms, thus filtering tremors. The high-magnification, three-dimensional, high-definition image at the surgeon's console and the articulated robotic arms provide improved visualization of lateral-based structures, and enables direct visualization at and around the tumor, which helps to compensate for the lack of haptic feedback.⁸ The main drawbacks of TORS for resection of large PPST include limited exposure of lateral and posterior aspects of the PPS.^{9,10} In the transoral robotic approach, the PPST is situated between the robotic arm and the carotid artery. In cases in which the tumor cannot be manipulated by the robot, finger dissection, and separation of the tumor from the mouth or neck is necessary. The traditional finger dissection, whether performed from the neck or the mouth increases the risk of neurovascular injury and tumor spillage. Here, we use a four-hand transcervical endoscopic technique to circumferentially separate the tumor from the neurovascular structures of the neck. After the tumor is separated and mobilized, it is removed through the neck. For tumors too large to be removed through the neck, we use a complementary transoral robotic approach that enables safe removal of the tumor through the mouth while maintaining minimal pressure on the tumor capsule.

Materials and Methods

We retrospectively studied the demographic, clinical, surgical, and outcome data of 11 consecutive patients who underwent PPST excision at our center between June 2013 and July 2017. Patients either underwent a transcervical endoscopic procedure ($n = 4$), a transoral robotic procedure ($n = 2$), or a combination of the two procedures ($n = 5$), depending on tumor size and location.

Surgical Technique

Transcervical Endoscopic Approach

Patients undergoing the transcervical endoscopic approach are orally intubated before anesthesia, whereas those undergoing TORS or the combined approach are nasally intubated. In all cases, surgery is performed under general anesthesia in a supine position. For the transcervical approach, an incision of 4 cm is made along a transverse skin crest, 4 cm below the

ramus of the mandible. Subsequent dissection of the subcutaneous tissue and the platysma is performed with an electrocautery at the lowest effective setting. A superior subplatysmal flap is elevated to the level of the mandible and dissection continues along the superficial layer of the deep cervical fascia investing the sternocleidomastoid muscle. After exposing and preserving the spinal accessory nerve, the posterior belly of the digastric and stylohyoid muscle is identified and divided. The styloid process and the stylomandibular ligament are identified and cut to improve exposure. Next, the internal jugular vein, common carotid artery and its branches are identified. The dissection continues cephalad along the common carotid artery. At this stage, a 0-degree endoscope (KARL STORZ, Tuttlingen, Germany) is delivered through the tunnel into the depth of the surgical incision. Exposure is achieved with the aid of two Langenbeck retractors. The tumor is identified at the poststyloid space after dividing the superior pharyngeal constrictor muscle and the medial pterygoid muscle (►Fig. 1). The ascending pharyngeal artery and the hypoglossal nerve are identified and preserved (►Fig. 1C, D). At this step, the dissection is aimed to expose the superior pole of the tumor and define its upper limit. Endonasal skull base surgical instruments, including micro dissectors, microscissors, and tumor grasping forceps, are used. The dissection continues along the inferolateral aspect of the tumor capsule parallel and anterior to the internal carotid artery around the tumor and superiorly up to its attachment to the skull base. The tumor's association with the cranial nerves is then explored. Extracapsular circumferential separation of the tumor from the surrounding tissues is meticulously performed to free the tumor from most or all of the surrounding tissue. The wound is irrigated and covered with moist gauze. In cases of small tumors for which complete circumferential separation was possible, the tumor mass is delivered through the cervical incision.

Transoral Robotic Approach

In cases of large tumors located high and laterally at the skull base, or tumors connected to the deep lobe of the parotid gland, a complementary TORS approach is undertaken to achieve complete circumferential dissection. For this procedure, a Feyh-Kastenbauer (FK) laryngeal retractor (Gyrus AMI, Southborough, Massachusetts, United States) is used. The da Vinci Surgical System (Intuitive Surgical, Inc., Sunnyvale, California, United States) is docked at the right side of the patient's bed. An 8-mm camera at a 0-degree angle is installed and inserted into the mouth. The robotic arm ipsilateral to the lesion is installed with a 5-mm monopolar cautery with a spatula tip, and the contralateral arm with a 5-mm Maryland dissector. The robotic arms are positioned, so that instrument tips were within the field of view of the endoscope with minimal angulation. A second surgeon at the head of the bed assists with a pediatric Yankauer suction and bipolar cautery. An inverted hockey stick mucosal incision is performed at the lateral aspect of the palatoglossal fold, using the monopolar cautery of the robot's arm. An oropharyngeal flap is elevated caudally. Next, a deep dissection through the superior constrictor muscle is performed with the monopolar cautery. The dissection continues toward the

Fig. 1 Tumor exposure: Transcranial endoscopic approach. (A) Extracapsular circumferential separation of the tumor from the surrounding tissues until 360 degrees is achieved. (B) Dissection along the inferolateral aspect of the tumor capsule exposes and defines its surrounding limits. (C) The dissection is performed in parallel and anteriorly to the internal carotid artery superiorly up to its attachment to the skull base avoiding the hypoglossal nerve. (D) Hypoglossal nerve (black arrow) and lingual nerve (black asterisk) are identified and preserved.

PPS, through the superior constrictor, and medial to the pterygoid muscles extending to the parapharyngeal fat. The tumor is identified and grasped gently by the robotic arms. Using the robotic arms, further separation of the tumor from its surrounding tissue, including the parotid gland at the depth, is performed, until 360 degrees severance is achieved. The intact tumor mass is delivered per orally. The wound is copiously irrigated, and hemostasis is achieved with a bipolar electrocautery. A Jackson-Pratt number 7 drain is left in the surgical bed through the neck. The platysma is closed with 4-0 absorbable Vicryl stitches (Ethicon Inc.) and the skin is closed with intracuticular suture using 5-0 absorbable Biosyn stitches (Medtronic). The oropharyngeal flaps are sutured in place with a number 2.0 absorbable braided suture (V-Loc, Covidien). Tumor specimens are submitted to the pathology laboratory for analysis.

Results

The case series is comprised of three males and eight females with a mean age of 54.18 ± 15.96 years (range: 30–78 years).

The patients' demographic and clinical data are summarized in ► **Table 1**.

Preoperative fine-needle cytology results suggested benign tumors for six patients and were non-conclusive for five patients. Complete tumor excision was achieved in all cases, with no intra-, peri- or postoperative complications. The average tumor size was $44.22 \pm 31.9 \text{ cm}^3$ (range: 7.5–111 cm^3). The mean total operative time was 124.66 ± 0.64 minutes (range: 77–170 minutes). There were no events of postoperative bleeding. Immediate postoperative neurological exam of cranial nerves was normal. There was a slight weakness of the marginal mandibular branch of the facial nerve in two patients, which resolved completely within 3 months. Oral intake was reinstated within 6 to 48 hours after surgery with no evidence of speech or swallowing difficulties. There were no events of first bite syndrome. Mean hospitalization duration was 3.36 ± 1.68 days (range: 2–8 days). Although the preoperative evaluation of the tumors suggested a benign pathology, the final histopathologic findings demonstrated pleomorphic adenoma for seven patients (63.63%), cavernous hemangioma for one patient (9%) and malignant tumors for three patients (27.27%).

Table 1 Clinical and demographic characteristics

Age (y)	Gender F / M	Approach	Operation duration (h)		Tumor size (cm ³)	Complications	Postoperative hospitalization duration (d)	Final histopathology	3–4 mo follow-up	Oncological treatments after surgery
66	F	TORS	1.416		111	None	8	PMA	Full recovery No evidence of residual tumor at MRI	None
78	F	Combined TCE-TORS	2.67		28	None	3	PMA	Full recovery No evidence of residual tumor at MRI	None
42	M	Combined TCE-TORS	2.83		36	None	3	CXPA	Full recovery No evidence of residual tumor at MRI	None
69	F	Combined TCE-TORS	2.83		32	None	4	CXPA	Full recovery No evidence of residual tumor at MRI	Radiation
30	M	Combined TCE-TORS	2.73		80.19	None	3	Adenocarcinoma	Full recovery. Marginal mandibular branch weakness resolved	Radiation
33	M	Combined TCE-TORS	2.1667		60	None	3	PMA	Full recovery	None
61	F	TCE	2.2167		33.75	None	2	PMA	Full recovery. Marginal mandibular branch weakness resolved	None
38	F	TCE	1.633		7.5	None	3	PMA	Full recovery	None
60	F	TCE	1.283		18.5	None	2	PMA	Full recovery	None
64	F	TORS	1.98		67.5	None	4	PMA	Full recovery	None
55	F	TCE	1.1		12	None	2	Cavernous hemangioma	Full recovery	None

Abbreviations: CXPA, carcinoma ex pleomorphic adenoma; F, female; H, hours; M, male; MRI, magnetic resonance imaging; PMA, pleomorphic adenoma; POD, postoperative day; TCE, transcervical endoscopic; TORS, transoral robotic surgery; Y, years.

Fig. 2 Preoperative axial (A) and coronal (B) and 3 months postoperative axial (C) and coronal (D) T1-weighted gadolinium-enhanced magnetic resonance images of a 30-year-old patient with adenocarcinoma at the right PPS. PPS, parapharyngeal space.

The malignant tumors included two ex pleomorphic adenomas and one adenocarcinoma (►Fig. 2A, B). Two patients required further radiation treatment. The radiation was provided using V-MAT (volumetric modulated arc therapy) to a dose of 54 Gy to the tumor bed. In one case of a 42-year-old otherwise healthy male who presented at our clinic with asymptomatic right soft palate bulging, magnetic resonance imaging (MRI) showed right PPST (►Fig. 3A, B). Preoperative fine-needle aspiration (FNA) was suggestive for pleomorphic adenoma. He underwent PPST resection via the combined approach. Histopathology results showed encapsulated carcinoma ex pleomorphic adenoma (an entity with benign features) that was resected completely, with no evidence of invasion. Thus he did not require further treatment. Postoperative MRI images showed no evidence of recurrence in any of the patients (follow-up range of 3–48 months) (►Figs. 2C, D; 3C, D).

Discussion

Tumors of the PPS are traditionally resected using transcervical or transparotid approaches, typically requiring blunt dissection from tactile feedback. The first time that the da Vinci robotic

system (Intuitive Surgical, Inc.) was used to excise a PPS mass was in 2007.¹¹ Given that the majority of parapharyngeal neoplasms are benign, it is important to demonstrate that any new technology used to excise these tumors is safe and minimizes morbidity. Regardless of the approach, the potential complications of resecting PPS tumors include: tumor spillage; transient or permanent injury to cranial nerves VII, IX, X, XI, and XII; hemorrhage; stroke; first bite syndrome; and Horner syndrome. Owing to the high risk of tumor spillage, cranial nerve injury and bleeding resulting from inadequate excision, we developed an alternative novel approach in which transcervical endoscopic dissection is combined with TORS. This combined approach offers improved visualization and allows meticulous dissection of the tumor from the adjacent neurovascular structures. Tumor removal is safe, with minimal morbidity and excellent functional and cosmetic outcomes. Transoral removal is utilized when transcervical resection is associated with high risk of tumor spillage.^{3,10} In cases of large PPS tumors, removal through the neck can be limited by the mandible and spine. For these cases, the stylomandibular ligament is divided, allowing complete tumor removal through the mouth. This technique allows safe, under vision transcervical - transoral mobilization

Fig. 3 Preoperative axial (A) and coronal (B) and 3 months postoperative axial (C) and coronal (D) T1-weighted gadolinium-enhanced magnetic resonance images of a 42-year-old patient with encapsulated carcinoma ex pleomorphic adenoma at the right PPS. PPS, parapharyngeal space.

and delivery of the tumor through the mouth. This combination enables the removal of huge tumors with superior PPS extension, as well as low-grade malignant tumors involving the skull base or jugular foramen in a minimally invasive technique. In cases of high and laterally located tumors, the TORS approach alone is limited by the inability of the robot to visualize and dissect laterally adequately. In these cases, the tumor is typically freed by the release of the stylomandibular ligament and blunt finger dissection over the digastric muscle without facial nerve identification,³ a procedure that risks the integrity of the nerve and thus facial nerve function postoperatively. Boyce et al.³ describe the largest single-institution case series to date of 17 patients who underwent transoral robotic excision of PPS tumors. The average tumor size was 27.3 cm³ (range: 2–80 cm³). Tumor removal was successful in all cases, with two patients (11.7%) requiring a cervical incision to assist with tumor removal. Two PPS pleomorphic adenomas had focal areas of capsule rupture, and one was fragmented. Three patients (17%) experienced complications. This complication rate is higher than that reported by Chan et al (5%) but comparable to other large review series that report rates of 12 to 29%.^{10–13} There was no clinical or radiographic evidence of recurrence. Three patients with pleomorphic adenomas in the series had disruption of the capsule for an overall rate of 27%, which is similar to the percentage published in the review of TORS by Chan et al.¹⁰ De Virgilio et al report that tumors approaching the stylomandibular tunnel could be excised with TORS, but a

controlled disruption of the capsule with debulking was needed for complete excision.¹⁴ Betka et al report capsule rupture in two patients with PPS pleomorphic adenomas who underwent transoral excision without using the robotic system, with no evidence of recurrence.¹⁵ Capsular disruption is undesirable; Historical recurrence rates of up to 45% were reported in an era of extracapsular enucleation. Hughes et al. noted macroscopic capsular disruption in 15% of PPS pleomorphic adenomas but reported a recurrence rate of only 4% in their series, with follow-up of over 20 years.¹³ The majority of these patients underwent either a transcervical or transparotid approach. In our series, PPST were removed successfully in all cases. The average size of the tumors was 44.22 ± 31.9 cm³ (range: 7.5–111 cm³), 5 cm mean the largest dimension (range: 3–6 cm). None of the patients experienced major complications. There was no clinical or radiographic evidence of recurrence at up to 4 years follow-up. The patients with malignant tumors had no signs of local invasion on imaging (computed tomography and MRI). All the tumors were resected completely with no spillage and with negative margins. Preoperative FNA was performed in all patients, and was suggestive of benign cytology. The patients underwent combined endoscopic transcervical-robotic transoral approach. Intraoperative frozen sections were obtained during surgery and only in one case; intraoperative evaluation was suggestive of carcinoma. The other two tumors were encapsulated, with only approximately 30% of the tumor comprised of carcinoma and their intraoperative diagnosis was benign. Surgery in this technique was aimed for complete resection, without spillage and achieved negative margins. Since the imaging modality showed encapsulated tumors without any evidence of invasion, the prior suggestion of malignancy on FNA would not have changed our surgical plan. In a retrospective review of 47 patients with parapharyngeal space tumors (12 with malignant diseases and 35 with benign lesions) treated by the same surgeon, we found a higher rate of complications in comparison with the current series.¹⁶ In this historical cohort, an open transcervical (40%) or a transcervical-transparotid approach (46%) were most commonly used, followed by the orbitozygomatic-middle fossa approach (12%) and the transmandibular approach (2%). The most common postoperative complication in this series was facial nerve palsy. This occurred in five patients (all branches in one patient and the marginal mandibular nerve in four patients) with spontaneous resolution in all cases. Other complications included pulmonary embolism, a decubitus wound and Frey syndrome.¹⁶ Although there is a selection bias between these two studies, the comparison emphasizes the safety of the minimally invasive approaches presented in the current paper. The indications for the combined approach are: (1) High small benign PPS tumors such as pleomorphic adenomas which are difficult to reach by blunt dissection, and difficult to visualize adequately and dissect laterally by TORS approach alone; (2) large pleomorphic adenomas of the PPS; (3) encapsulated carcinoma ex pleomorphic adenomas or adenocarcinomas without extracapsular extension; (4) symptomatic PPS schwannomas. In this paper we describe the addition of a transcervical endoscopic approach to the PPS. Transcervical-robotic surgery could potentially be used as an alternative to the transcervical endoscopic approach

for safe separation and mobilization of the lower and posterior aspects of the tumor. Further studies are required to outline the advantages and disadvantages of this approach to the PPS.

Conclusions

We describe the first series of combined endoscopic-transoral robotic approach for PPS tumor removal. The technique provides improved visualization, safe vascular control, and minimal tumor stress, eliminating the need of blunt/blind finger dissections. This approach achieves complete tumor removal while minimizing the risk of tumor spillage, nerve injury and blood loss. It can be utilized for the removal of large PPST as well as small malignant tumors.

Conflict of Interest

None.

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