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Minimally invasive management of parapharyngeal space tumors: Introducing a decision-making algorithm and radiologic tool

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Publikation

Minimally invasive management of parapharyngeal space tumors: Introducing a decision- making algorithm and radiologic tool

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Abstract
Objective: Traditionally tumors of the parapharyngeal space (PPS) are resected through transcervical approaches. More recent approaches include endoscopic approaches or trans oral robotic surgery (TORS) without directions when to use which approach. Our objective was to find objective parameters to choose the most suitable approach.

Methods: It is a retrospective study containing 6 patients from May 2019 to May 2021 with tumors of the PPS in the Department of Otolaryngology and Head Neck Surgery at the Hospital of Lucerne, Switzelrand

Results: The data was analysed in average 53 months after surgery. Tumor resection was completed with TORS in 3 patients, endoscopical in 3 patients. Mean operation time was 114 min (51 min-178 min). No major complications occurred. No evidence of tumor was found in magnetic resonance imaging studies postoperatively in all patients.

Conclusion: We conclude that a resection via TORS or endoscopical technique is safe and effective. Furthermore, we postulate that the further a tumor is located in the upper lateral area of the PPS, an approach via TORS is not possible.

Keywords
Oto-Rhino-Laryngology; Endoscopic surgery; Robotic surgery; Parapharyngeal space tumors

1. Introduction

Parapharyngeal space tumors (PPST) are a rare entity and are responsible for 0.5% of all head and neck tumors.[1] Eighty percent of the PPST are benign in nature. The most common benign lesions are pleomorphic adenomas of the deep parotic lobe, followed by schwannoma.[2] Salivary neoplasms are the most frequent malignant tumors.[3]

The parapharyngeal space (PPS) is divided into two distinct compartments: The prestyloid and the poststyloid region. The anatomic separation of these two regions is the styloid diaphragm which consists of the muscles and ligaments originating from the styloid process. Each of these two regions harbors different anatomical structures, out of which distinct pathologies can arise.

The poststyloid region contains the neurovascular bundle of the carotid space with the internal carotid artery, the internal jugular vein and the lower cranial nerves as well as sympathetic trunk. The prestyloid region houses branches of the external carotid artery and the deep lobe of the parotid gland. The PPS is frequently compared to an inverted pyramid with the base formed by the greater wing of the sphenoid at the skull base, the lateral border consisting of the medial pterygoid muscle, the vertical ramus of the mandibula, the deep lobe of the parotic gland and the posterior belly of the digastric muscle. The medial wall is formed by the superior constrictor muscle. The prevertebral fascia forms the posterior wall and the apex is represented by the greater cornu of the hyoid bone.[4,5] In a coronal plane the PPS is further divided in 3 sub-compartments.[6] The separation is made between the upper and middle part at the level of the inferior border of the lateral pterygoid muscle and the middle and the inferior part at an imaginary line joining the angles of the mandibula.[4] Identifying the involved compartment and space by the tumor is crucial for the differential diagnosis and the planning of the surgical approach.

Traditionally tumors of the PPS are resected through transcervical, transparotideal or transmandibular approaches. These approaches have a relatively high morbidity such as first bite syndrome, salivary cutaneous fistula or mandibular non-union among other disadvantages such as longer operating times, prolonged recovery and hospitalization.[7] Because of the above, the introduction of transoral endoscopic and robotic approaches have emerged as alternative routes with significantly less morbidity. Despite being already described by Goodwin and Chandler in the 1980s,[5] prior to the implementation of endoscopic and robotic technologies, due to the limited exposure to the PPST with risk of hemorrhage, incomplete tumor resection or tumor spillage and facial nerve injury,[2] the indications for a removal of PPST via transoral approaches were limited.

The selection of the optimal surgical approach for a safe resection is typically determined by the pathologic nature, the tumor size and the location particularly regarding the superior and lateral extent and proximity to the neurovascular structures. Preoperative workup usually entails a computed tomography scan or preferably, a magnetic resonance imaging (MRI) as it provides more information about the tumor type and its relationship to the surrounding soft tissue and the parotid gland. If feasible, a transoral or transcervical fine needle aspiration cytology (FNAC) is conducted to determine the pathological nature of the tumor preoperatively.

With the technical innovations in endoscopic and robotic surgery over the last decade, the transoral approaches to the PPST have become increasingly popular. With this case series, we wanted to investigate the option of treating the PPST through transoral approaches and further develop a tool to assist the surgical planning of the transoral PPST removal regarding whether to approach a PPST with the trans oral robotic system (TORS) or via a transoral endoscopic approach. We considered the anatomical and technical limitations in approaching a PPST via the various transoral operation techniques and how this could be used for surgical planning. Additionally, we conducted a review of the published literature on the transoral removal of parapharyngeal tumors.

2. Material and methods

2.1 Patients

We retrospectively studied patients with PPST treated at a tertiary Head & Neck center, Hospital of Lucerne, Switzerland between May 2019 and May 2021. All patients with PPST were treated in the time period between May 2019 till May 2021. Exclusion criteria: Children, trismus, tumor recurrence, coagulation disorders and if the size of the tumor or the patient was not eligible for a transoral operation or in presence of signs of malignancy. Of the recruited patients, the medical records were retrospectively reviewed and analyzed. The data included, sex, age, symptoms, tumor sizes, complications, follow up and outcomes. Additionally, the imaging data and the surgical trajectories were analyzed with regard to the access to the superior and lateral extensions of the tumor factoring in the anatomical limitations such as the pterygoid plates and the maxillae with regard to an endoscopic or robotic access.

2.2 Radiologic assessment

With the data obtained from the MRI we performed a planimetric volume distribution. The measurements were conducted on a multiplanar reconstruction of a sagittal acquired 3- dimensional sequence. First, the horizontal plane was adjusted parallel to the plane of the hard palate. In the next step, in the axial plane, the sagittal plane was adjusted to run along the medial border of the alveolar ridge. In the last step, the intersection of the 2 above mentioned planes was projected over the tumor in a paracoronal plane. In applicable scenarios the volumina of tumor subunits laying between those planes were planimetrically measured using the Syngo. via software (Version VB40, Siemens, Forchheim, Germany). (Figs. 1 and 2).

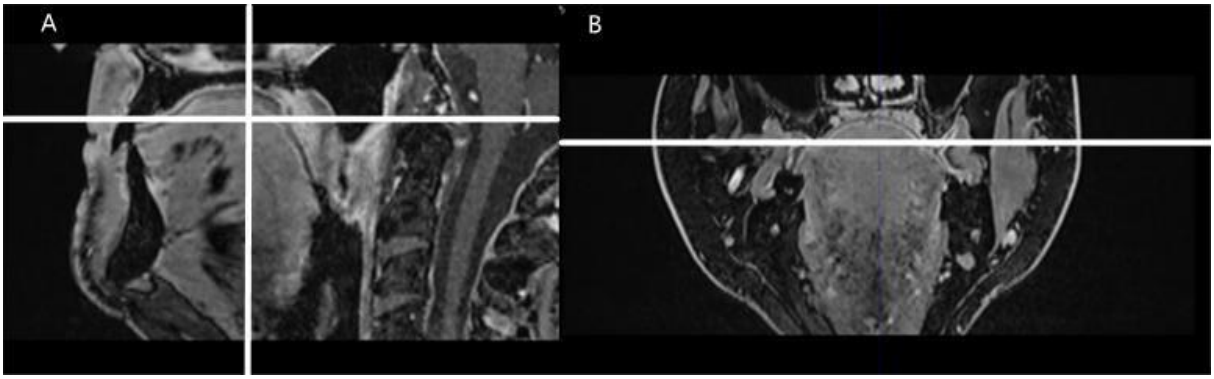

Fig. 1 Planimetric calculation

A, In a sagittal plane, a parallel line to the palatum durum is placed. B, In a coronal plane, the tubera maxillae are identified and a horizontal line is placed.

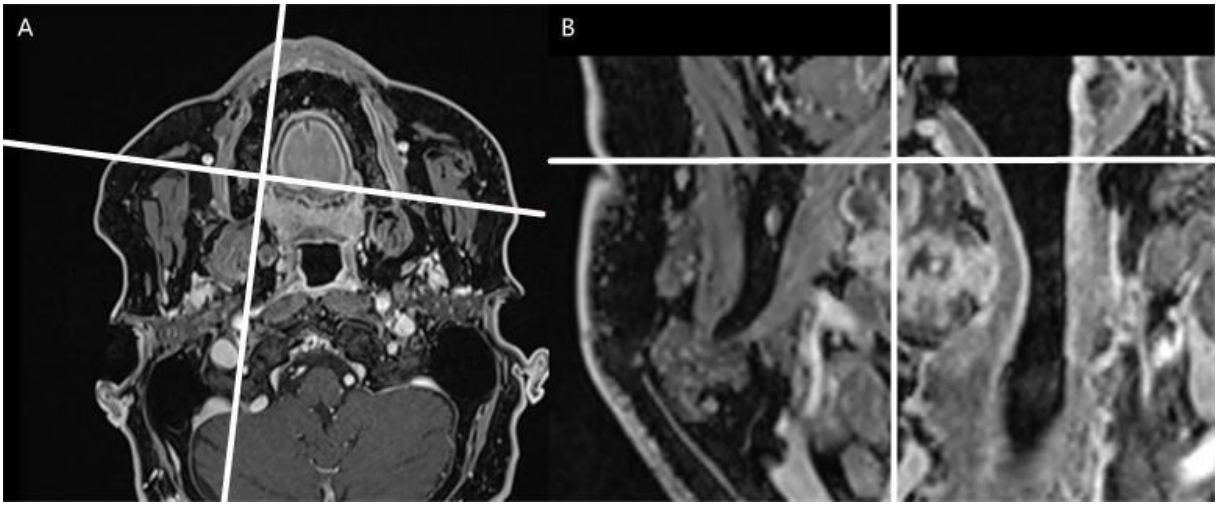

Fig. 2 Planimetric calculation
A, A line is set in an axial plane alongside the inner line of the maxilla. B, The lines are driven backwards towards the tumor.

2.3 Algorithm setup
Resulting planes permit the allocation of the tumor volumes and spaces into 4 quadrants. For each tumor the volume component in respective quadrants was calculated in relation to the total tumor volume. Intraoperative reports were retrospectively analyzed in order to determine if the chosen approach was suitable for the tumor size and distribution based on the above-mentioned segmentation.

3. Results

Three patients were males, 3 were females. The mean age was 62.8 y. All patients received preoperative MRI. The largest tumor volume was 62 mL. The mean tumor volume was 26 mL. Tumor resection was performed via TORS in 2 patients and endoscopically in 3 patients.
In 1 patient, the operation had to be converted from a TORS approach to an endoscopic approach. No conversion to an external approach was required in the cohort. Tumor removal was complete in all cases. Mean operation time was 114 min (51 min-178 min). All patients were treated with postoperative oral antibiotics for 7 days. No major perioperative or postoperative complications occurred in the cohort. Two patients had peritonsillar wound dehiscence which resolved under regular antiseptic mouthwashes. Histology demonstrated pleomorphic adenoma in all cases. No evidence of residual tumor was found in the 6-month serial MRI follow up so far. Average follow-up was 53 months after surgery (Table 1).

Table 1 Overview of the patients' tumors and their volume distribution

Patient	Volume (mL)	Volume ULQ (mL)	Ratio	Operative technique
1	11.7	0	0	TORS
2	5.1	5.1	1.00	TORS converted
3	50.5	8.6	0.17	Endoscopic
4	61.7	6.1	0.10	TORS
5	11.4	3.9	0.34	Endoscopic
6	12.7	4.5	0.35	Endoscopic

ULQ, upper lateral quadrant; TORS, trans oral robotic surgery.

Ratio: The volume in the upper lateral quadrant divided by the total volume results.

4. Discussion

None of our patients was symptomatic at diagnosis, which is a common finding in PPST, they are mostly identified as an incidentaloma during investigations for other reasons, this is also the reason why the PPST tend to have a frequently impressive size at diagnosis. Far less frequent signs or symptoms are an external or intraoral mass, otalgia and dysphagia.[2] Trismus and nerve paralysis are red flags for potential malignant disease. The pathology of the PPST is crucial for its further management. Commonly the MRI pattern of the PPST is highly accurate to establish the diagnosis. Certain radiologic features such as the fat cap sign-which is the anteromedially displaced parapharyngeal fat pad is suggestive for a tumor arising from the deep lobe of the parotic gland. A lateral displacement of the fat pad is an indicator that the tumor might have its origin in the minor salivary glands of the palate.

A displacement of both the carotid artery and V. jugularis interna posteriorly suggests the tumor arising from the prestyloidal space. Poststyloidal tumors tend to separate the V. jugularis interna from the A. carotis interna.[8] Usually prestyloid masses push the carotid artery posteriorly whereas a poststyloid mass displaces the carotid artery in an anterior-medial direction.[7] In unclear cases, a FNAC can be obtained transorally under ultra sound guidance with a moderately high rate of non-diagnostic results.[9] In our cohort, one patient received a FNAC with a non-conclusive result. Some authors propose intraoperatively frozen section biopsy in unclear cases and report a high diagnostic accuracy.[10] There is a low incidence of complications in the literature with low rate of lesions to major vessels or nerves.[11] Two patients in our cohort exhibited peritonsillar wound dehiscence, which resolved under regular antiseptic mouthwashes and did not result in long term sequelae.

Choosing an appropriate approach is fundamental for a complete and safe removal of PPTS. Besides the surgical skills and experience of the surgeon, the most important factors affecting the decision-making is the location of the tumor and the patient's individual anatomy of the maxilla and PPS. The decision to adopt a transoral approach was primarily based on the MRI findings. If the tumor had originated of the deep lobe of the parotic gland and was benign from the clinical aspect, we decided to choose a transoral approach. There are several surgical approaches described in the literature to approach PPST. Most frequently cervical or combined transparotid approaches are used to approach PPST. A cervical approach is useful for most extraparotid masses situated in the inferior part of the PPS. The transparotid approach is used when the facial nerve is potentially involved. These approaches are combined with a mandibulotomy in large, recurrent or malignant tumors requiring maximal exposure. The infratemporal approach is used in combination with the cervical or transparotid approach for lesions approaching the skull base or with intracranial extension.[2] Motta et al. proposed a chart when to opt for a transoral approach. In their opinion, presence of an oropharyngeal bulge without being evident at any level of the neck, clinical and radiological benignity and posterior dislocation of the major vessels leads them to evaluate a transoral approach.[12]

The transoral approach offers many advantages including less harm to the facial nerve, no risk of fistulas, shorter hospitalization time and no cosmetic deformities.[13] Despite that, transoral approaches are rarely used for the removal of PPST, Riffat et al. reported that only in 2% of their large PPST series a transoral approach was used. In their opinion the limited exposure leads to a higher risk for tumor rupture, incomplete removal, hemorrhage and facial nerve injury.[2] In the last decade transoral approaches, mainly via endoscopic approach have become more common and

described as a feasible and safe option for PPST resection.[14- 16] But still removal of tumors extending close to the skull base is a challenge no matter what approach is used as visualization of the superior extent is limited for the standard approaches. It would be useful to have a tool which on one hand can help decide which PPST can be approached safely transorally and on the other hand aids in the decision on what transoral technique to use, endoscopic versus the robotic route. This lack of a decision-making tool leads us to investigate whether such a tool could be developed so that decision-making could be standardized with regard to the choice of the most adequate transoral approach for a safe and complete resection of the tumor mass. If we think of limitations in addressing a tumor of the PPS there are anatomical boundaries, limitations of the operating system in terms of range of motion and characteristics of a tumor itself. In addition, a limited mouth opening or trismus-limits the exposure dramatically and is considered a contraindication for a transoral approach. Profound relaxation of the patient is therefore mandatory for adequate exposure. If we think of anatomic boundaries a vertical grown maxilla which is high and narrow is a major factor for a limited approach. In addition, if the posterior distance between the molars is small and/or if the ratio between the posterior distance (molar) and the anterior distance (praemolars) is small the angle of the maxilla is narrow. Consequently, surgical approach to the PPS is limited. These different aspects led us to the creation of a ratio taking into account the different limiting anatomical aspects. Iseri et al. described difficulties approaching tumors of the PPS, especially to dissect the posterior and lateral boundaries.[13] Iglesisa-Moreno and his group postulated that especially the distance to the skull base affects their decision making.[17] We made similar experiences in approaching PPST transorally. Especially it's parts in the upper lateral quadrant, as divided by above mentioned planes, is difficult to approach In our experience, it is necessary not only to define the location of the tumor in its macro- but also to further estimate its location in the microenvironment. Where exactly within the PPS the tumor is located? Which proportions are located in which parts of the PPS. The lower, medial proportions of the tumor are easily addressed via transoral resection. But the more lateral and the more superior the dissection gets, the more difficult it gets for a safe and complete resection. It is the lateral superior extension of a parapharyngeal tumor which has a major impact on approaching a tumor transorally and therefore determines the operation technique-endoscopic or robotic. This led us to the calculation of the tumor volume located in the upper lateral quadrant (VULQ) in relation to the total tumor volume (Figs. 3 and 4). The obtained ratio gives the surgeon an idea of the tumor distribution and helps determining the most adequate surgical tool for a safe and complete tumor resection with regard to transoral access.

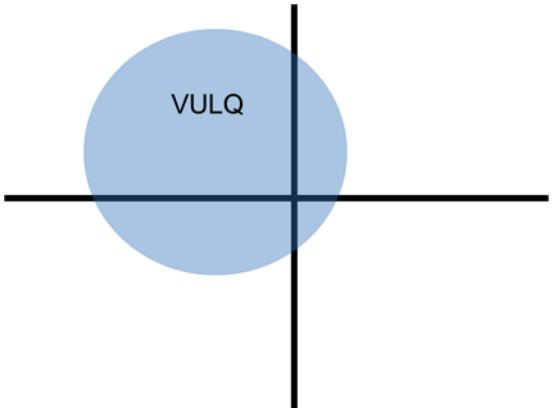

Fig. 3 Schematic demonstration of a PPST (blue dot)

The tumor is shown in a coronal plane in respect to the predefined lines. The volume in the upper lateral quadrant in respect to the total tumor mass defines the surgical approach. PPST, parapharyngeal space tumors; VULQ, volume in the upper lateral quadrant.

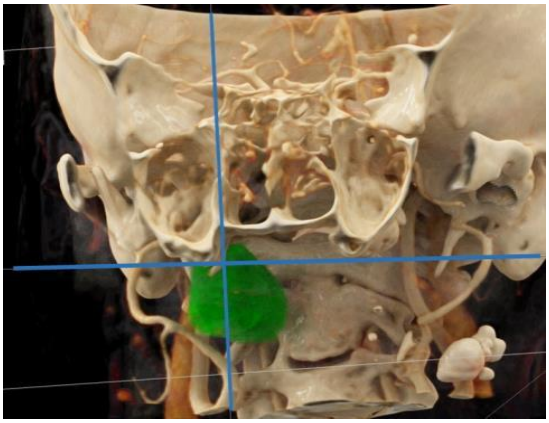

Fig. 4 Three-dimensional reconstruction
Image based on MRI data showing the position of the tumor (green) in respect to the horizontal and sagittal line in a coronal plane.

The da Vinci system allows fine motor control, a tremor filter and a magnified 3-dimensional vision and is the preferred operation technique. It allows a 120° range of motion in a horizontal plane and 120° degrees in a kranio-kaudal plane. In addition, it offers instruments with 7 degrees of freedom, 90° of articulation and a 540° rotation in the endowrist. The remote center of the da Vinci system is a fixed point around the arms and instruments of the robotic system move. This point is located outside the mouth to prevent instrument collision inside the mouth. When using the da Vinci system to approach the PPS the movement of the ipsilateral arm can be limited by maxilla. In addition, dentition and the tuber maxilla can limit the robotical access to certain parts of a tumor.
In contrast the endoscopic technique is a system with hardly any limitations,[18] and with the advantage of a tactile feedback in comparison with TORS (Fig. 5). Our analysis suggests that the more tumor volume lies in the ULQ, the less likely a TORS access will allow complete removal. In these cases, an endoscopic approach usually provides adequate exposure and range of motion. We are convinced that the more the volume of a tumor is located in the upper lateral quadrant, the more difficult it is to approach the tumor transorally in general and especially with the da Vinci system. In such cases, an endoscopical resection appears to offer full range of motion and adequate access in the upper lateral quadrant (ULQ). Our analysis of the surgical trajectories and the access possible by the robotic approach demonstrated that the ULQ was not accessible by the robotic approach in normal anatomic conditions. In other words, if the main tumor volume is located in the ULQ a removal via TORS is not possible. In the near and more distant future, further technical innovations will alter the way we do operations today. For example, the single port da Vinci system will facilitate the resection of tumors in the head and neck area and will probably also affect the management of parapharyngeal tumor resection.

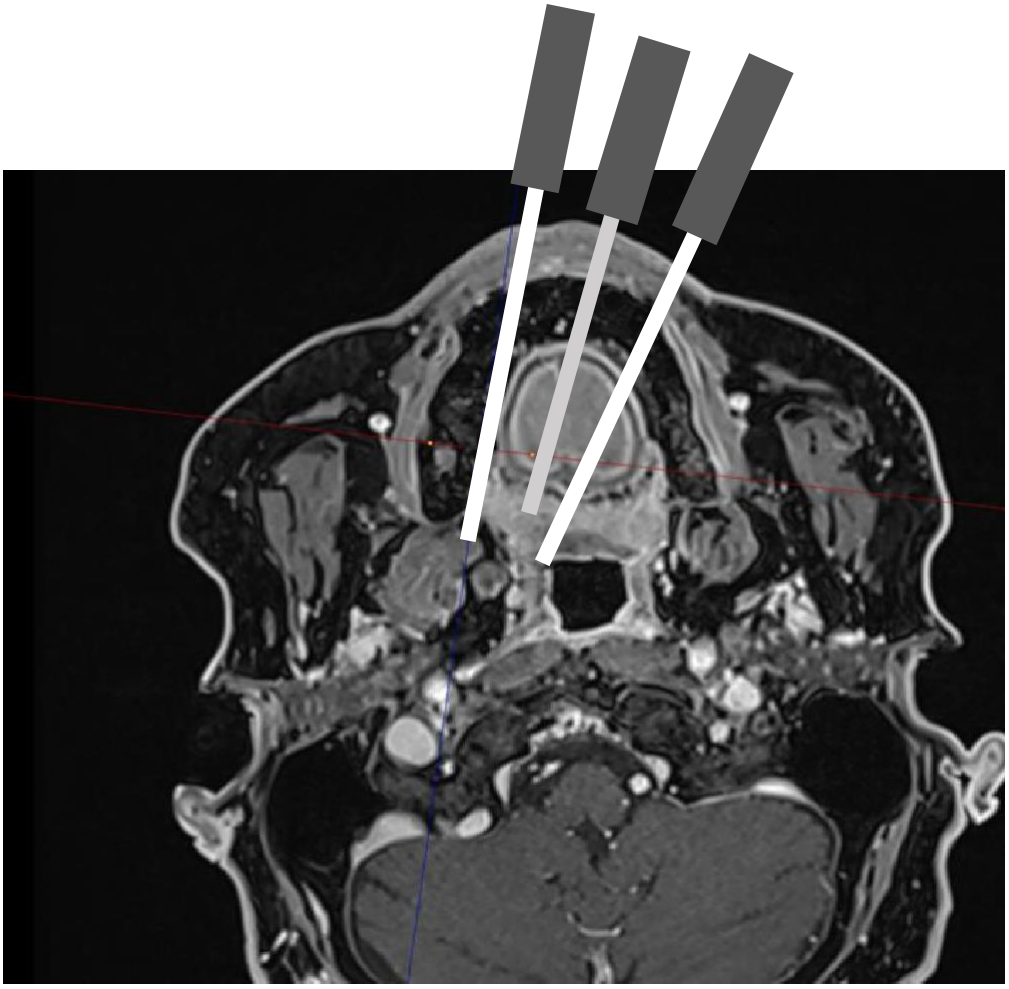

Fig. 5 Schematic demonstration of a transoral approach to the PPS
The two working arms and a camera arm are projected in an axial plane MRI data. PPS, parapharyngeal space; MRI, magnetic resonance imaging.

5. Conclusion

We conclude that the transoral resection of PPST via TORS or via endoscopic techniques are safe and effective surgical approaches and with these approaches benign tumors in the prestyloid region can be safely resected. [13] We propose to calculate the above-mentioned ratio to predict which transoral operation technique is the most adequate for a safe and

effective resection. To the best of our knowledge, we are the first to propose such a ratio to choose proper operation technique to approach PPST in a safe and effective manner. In the future, it would be beneficial to further validate the utility of our preoperative planimetric measurements for surgical planning. This could have a significant impact on preoperative decision-making regarding the optimal anatomical conditions for approaching the PPST with TORS or endoscopically. Therefore, a prospective study utilizing the planimetric calculation, potentially in combination with a model of dental impressions, is required to evaluate the efficacy of different transoral approaches.

Ethics approval

This study was approved by the Ethical Committee Nordwest und Zentralschweiz (EKNZ), 2023. In all cases, patient consent has been obtained.

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Verdankung und/oder Widmung

Ich danke meinem Grossvater H.J. Schoch, dass er mir gezeigt hat das immer alles möglich ist.

Curriculum Vitae

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