CHAPTER

6

Exoscope-assisted oropharyngeal surgery

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6.1 Introduction

The oropharynx is currently one of the most affected sites in head and neck oncology. Over the past 20 years, the incidence of oropharyngeal cancer has increased significantly, especially in younger people. This trend is clearly related to previous human papillomavirus infection.[1–5]

For advanced-stage oropharyngeal cancer, treatment generally includes at least two therapeutic modalities (surgery followed by radiation therapy or concurrent chemoradiotherapy), whereas for early disease treatment consists of surgery or radiation therapy alone. Radical surgery is particularly challenging because the oropharynx is involved in the crucial functions of swallowing, breathing, and speech, therefore early-stage cancers are frequently treated by radiation therapy alone.[6]

Historically, oncologic oropharyngeal surgery has been limited to open approaches (lateral pharyngotomy, pull-through, transmandibular approach), allowing excellent direct access to the disease, resulting in considerable functional and aesthetic sequelae. Therefore, nonsurgical organ preservation therapeutic options have progressively gained ground over time, guaranteeing similar oncological results, net of less invasiveness, and reduction of the impact on quality of life.

Following an initial enthusiastic spell, treatments based on chemoradiation protocols also demonstrated a significant rate of long-term dysfunctional sequelae, in turn extremely debilitating with a worsening of perceived quality of life. There was therefore a need to improve the options for surgical treatment allowing oncological and functional results similar to nonsurgical options to be obtained and minimizing the morbidity and the burden of treatments. This led to the development of minimally invasive transoral surgical techniques, such as laser and robotic surgery.

The recent introduction of 3D exoscopic surgery introduced interesting technical improvements in head and neck surgery, especially in transoral surgery, with the aims of replacing robotic surgery and minimizing the costs of the procedures.

Exoscope-Assisted Surgery in Otorhinolaryngology. https://doi.org/10.1016/B978-0-323-83168-0.00009-4
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In 2020, we have coined the term 3Dees (3D exoscopic/endoscopic surgery) to describe the use of the 3D VITOM Exoscope System/3D optics (Karl Storz, Tuttlingen, Germany) for the treatment of tumors of the oropharynx and oral cavity at an early-intermediate stage and to treat benign pathologies. Our aim has been to develop and rejuvenate the traditional transoral surgical technique with the addition of 3D screen vision, to analyze the efficacy and safety of the surgical procedures, and to test the system's ability in terms of surgical precision and shared surgical vision in comparison to transoral robotic surgery (TORS).

6.2 History

In 1951, Huet first described the transoral lateral oropharyngectomy (TLO) procedure for treating early invasive squamous cell carcinoma (SCC) of the tonsillar region.[7] TLO was reported to be an effective treatment option with safe oncologic outcomes for tumors of the lateral oropharyngeal wall, and it could represent an alternative to traditional aggressive surgical procedures, such as the transmandibular or transpharyngeal approaches.[8]

Lacourreye et al. reported 5-year local control rates of 89%–89.6% and 81.7%–85.8% in T1 and T2 oropharyngeal cancer treated with TLO, respectively. Moreover, other Authors reported 80% local control rate for selected oropharyngeal T3 and T4a.[9,10] Nevertheless, Huet's procedure did not achieve widespread acceptance among head and neck surgeons due to the narrow surgical field, which was difficult to reach because the first surgeon's view was limited (many tonsil and pharyngeal cancers are difficult or impossible to reach through the mouth under direct vision), and the poor maneuverability of surgical instruments.

In 2003, Steiner[11] attempted to overcome the drawbacks shown by TLO by introducing the use of microscope and transoral laser microsurgery (TLM) for the resection of oropharyngeal tumors, giving the surgeon better magnification and illumination of the surgical field. Although this was a significant improvement in transoral surgery allowing surgeons access to oropharyngeal sites that were hard to reach without an open approach, the microscope does not allow viewing around corners (it cannot be rotated along three-dimensional axes) while the 3D view is restricted to the first operator. In addition, it is only possible to execute straight/tangential cutting lines with the CO_2 laser, limiting the ability to make angled cuts around bulky structures or tumors.

To improve the efficacy of transoral access able to avoid the limitations of TLM, surgeons investigated the potential of surgical robotic platforms. TORS was performed for the first time in 2005 by Hockstein and colleagues,[12,13] while the earliest series of outcomes were published later by Weinstein, O'Malley, and colleagues.[14,15]

In recent years, several studies have shown that TORS may be an effective alternative to open surgery.[16–27] The high-resolution, magnified three-dimensional view of the operative field provided by TORS allows excellent visualization of the target area. Many other advantages have been highlighted: stable three-dimensional

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binocular magnification allowing “en bloc” resection to be performed with better identification of nerves and vessels; motion scaling; tremor filtration; a shortened learning curve and superior ergonomics for the surgeon. Moreover, surgery-associated morbidity is reduced with the robotic technique, improving functional outcomes compared to open approaches, and length of hospitalization is also reduced.

However, TORS faces some obstacles in pharyngeal and laryngeal surgery because the introduction of the robotic arms and instruments into narrow cavities can be difficult. Tumor exposure can be inadequate and can interfere with the robotic arms, and airway management can be challenging. In addition, the surgeon does not experience any intraoperative tactile feedback with this approach. Finally, robot-assisted surgery is costly with great obstacles to widespread uptake of this surgical option. Not all institutions have Da Vinci robotic platforms (Intuitive Surgical, Sunnyvale, CA), and there is often competition for the system among different specialties. Most hospitals cannot afford to purchase such an expensive device, particularly in developing countries.

6.3 3D exoscopic surgery by VITOM

Based on these considerations and keeping in mind that the oropharynx is easily accessible using a conventional surgical approach and that there may also be benefits from tactile feedback from the lesion, the introduction of the 3D VITOM Exoscope System has progressively spread. The aim is to improve surgical vision during the entire surgical procedure, and to reduced costs compared to robotic surgery when this approach is used.

Applied first in neurosurgery,[28,29] urology, and gynecologic surgery,[30] the use of VITOM is now starting to increase in ENT surgery as well. At present, only a few series have been reported in the Literature.[31,32]

6.4 Surgical procedure

6.4.1 Selection of patients

This is crucial in all types of transoral surgical procedures. Three categories should be considered when evaluating transoral candidacy: anatomic limits, patient comorbidities, and cancer characteristics. It is imperative to consider that unfavorable anatomy can impair adequate access and the view of the surgical field. Specific anatomic conditions could limit the exoscopic approach (reduced mandibular width, trismus with mouth opening <1.5 cm). Other anatomic restrictions, such as retrognathia and cervical spine inflexibility, do not represent an absolute contraindication to the use of VITOM as they are in robotic procedures. It is important to measure interincisive distance to estimate the ability of the transoral approach, and to provide good lesion exposure.

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In any case, if the extent of exposure does not result optimal to guarantee adequate oncological radicality, open approaches or non-surgical treatments should be considered.

6.4.2 Operating room setting

The patient is placed in a supine position without any interscapular support. The procedures are carried out under general anesthesia, performed with nasopharyngeal intubation or by tracheostomy with intubation. For the execution of lateral oropharyngectomy, the 90 degrees VITOM is assembled on a mechanical holder and with an autostatic arm attached to the bed at a distance of about 35–40 cm from the patient's mouth, along the visual axis between the surgeon's eye and the operative target, so replacing the vision of the whole surgical team. A sterile cover is then draped over the system. Using this holder, the exoscope is not easy to place and move. At this time, this is a weak point of the technique, that makes maneuvering and the disposition of the right operative setting less fluid. More recently, a latest-generation robotic holder (ARTip *cruise*) has been successfully proposed for VITOM.

The main 3D monitor (55 in.) is placed beside the operating table directly in front of the first surgeon, while a secondary 3D monitor is oriented in front of the assistant. An intuitive control unit with a 3D wheel (joystick) is used to control the camera, with four programmable function keys. Surgery is more comfortable when performed by three surgeons, but it is always possible for the first or second surgeon to adjust the controller as it is covered with a sterile coating, or where not covered, it can be maneuvered by other members of the surgical team not working directly in the operating field. A joystick (IMAGE1 PILOT) can also be attached to a holding system to be controlled directly by the first surgeon when needed.

The surgeon is positioned at the patient's head, facing the main monitor. The first assistant sits on the left/right of the surgeon (depending on the side of the lesion) and, during the procedure, helps using retractors, Yankauer suction tube, bipolar cautery, and by positioning vascular clips. The second assistant sits on the opposite side, using the controller (IMAGE1 PILOT) covered with a sterile coating, and maintaining the focus of the camera on the surgical field, adjusting the optical magnification, and applying different camera enhancing tools (Storz Professional Image Enhancement System (SPIES)). The scrub nurse stays behind the surgeon. All operators wear 3D passive-polarized glasses (Fig. 6.1).

To improve visualization of the base of the tongue and supraglottis, the VITOM can also be replaced by TIPCAM (Karl Storz), a 3D laparoscopic video endoscope (0 degrees or 30 degrees), 10 mm in diameter. TIPCAM benefits from well-known visualization modes for diagnosis and therapy with clearer differentiation of tissue structures (CLARA, CHROMA, and SPECTRA visualization modes) (Fig. 6.2).

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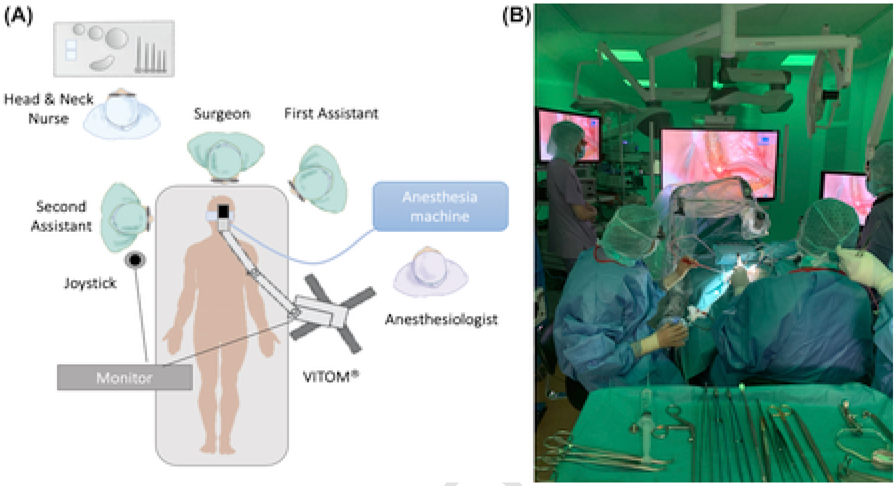

FIGURE 6.1

(A) Operating room setting with VITOM (scheme). (B) Operating room setting with VITOM (live surgery).

FIGURE 6.2

Operating room setting with TIPCAM (live surgery).

6.4.3 Surgical technique

A comfortable transoral exposure of the lesion is sought to visualize its boundaries completely and to have sufficient space to manipulate the surgical instruments. Different types of mouth retractors can be used. Surgical instruments should be at least 24 cm long (from 24 to 30 cm) because of the depth of the structures to be reached. Different kinds of cutting instruments can be used (bipolar scissors, CO_2 fiber laser, ultrasound tools), and various types of angled tools are also required.

When using the CO_2 fiber laser, it is mandatory to cover the nasotracheal tube with a wet swab or to use specifically designed tubes to avoid any possible fire in the airways. In any case, it is important to communicate with the anesthesiologist to reduce FiO_2 below 30% to prevent this eventuality, before using cautery or laser.

The characteristics of the 3Dees images are comparable to those of the operating microscope and the 3D optics of the Da Vinci system, due to their excellent ability to provide 3D visual information, that is used to interactively maneuver the exoscope camera. Other advantages are the depth of field, magnification, and image contrast and color, allowing effective manipulation of the anatomic structures. The most advantageous aspects are represented by the magnification of the anatomic details:the vascularization and irregularities of the mucosa are perfectly visible. The 3Dees provide a wide working space, and it is extremely useful for training and educational purposes. Both images and video sequences can be stored digitally.

Ergonomics is comfortable for the operator, who can choose to stay in a sitting or standing position, having the screen in front at the same height. Surgery performed with a 3D screen is not bothersome for operators, even for longer procedures, as long as the screen is placed frontally, and at the same height as the operator's eyes.

For the execution of the procedures, conventional surgical instruments can be used (no requirement to purchase other instruments), and this is undoubtedly an advantage in terms of immediacy, simplicity of use and low cost. Other hemostatic tools can be safely used (Focus, LigaSure, Thunderbeat, flexible CO_2 fiber laser, etc.) with complete visual control (Fig. 6.3).

We have applied the 3Dees approach for transoral resection of oropharyngeal SCC,[33] with or without neck dissection and reconstruction with free flaps. In our experience, most transoral surgical procedures enjoy the same benefits as provided by TORS, in terms of lower morbidity, fewer complications, and faster local healing and rehabilitation (Fig. 6.4).

Setup of 3Dees is easy and intuitive. This technique allows transoral surgery to be performed with indirect but straight visualization/magnification for the whole surgical team, and the team members are able to work with greater precision. Moreover, the exoscope allows the direct maneuverability of instruments providing a tactile sensibility, impossible to achieve when operating by TORS.

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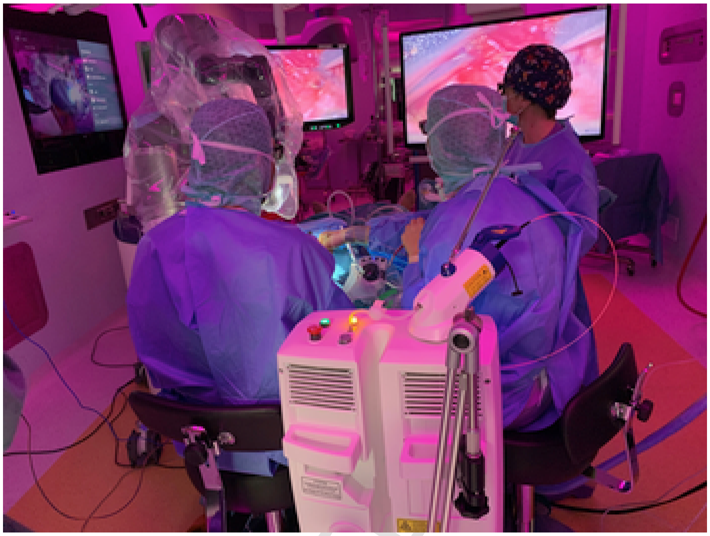

FIGURE 6.3

Operating room setting with VITOM and flexible CO_2 fiber laser (live surgery).

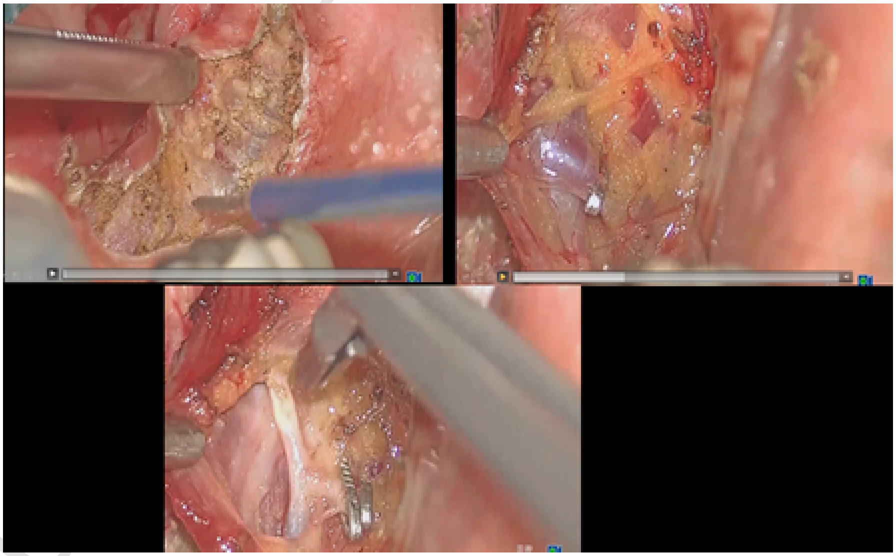

FIGURE 6.4

Transoral resection of oropharyngeal squamous cell carcinoma with VITOM.

The 3Dees approach can also have immediate and straightforward application in non oncologic surgical procedures (tonsillectomy,lateral pharyngoplasty, etc.) (Fig. 6.5). During reconstruction, the approach can be useful while insetting a free flap in the oral cavity/oropharynx without opening the mandible, since the vision provided by the exoscope facilitates transoral suturing of the flap to the mucosa. The combination of enhanced vision and use of a barbed suture is helpful in reducing operating time and fistula rate (Fig. 6.6).

Furthermore, the 3D exoscope permits a careful endoscopic work-up, which is useful in checking the correct surgical field exposure and in completing a good and safe resection by TORS. A well-executed work-up can also save time during setting up for robotic surgery, for example, by assessing beforehand which self-retaining retractor to use (Fig. 6.7).

Finally, 3Dees is extremely beneficial in the learning process, especially for residents, fellows, students, and OR staff, thanks to the shared visual experience available to all operators, and always with wide high-resolution screens.

3Dees can guide the trainees' surgical maneuvers, and thus they may gain confidence in navigating the anatomic structures and in performing microsurgical techniques while watching directly on the 3D screen. The inside-out anatomic study and the indispensable knowledge for surgeons who undertake transoral surgery of the oropharynx are facilitated by the 3Dees approach, for both the fidelity of vision and equipment logistics that makes it more easily transportable in the cadaver lab than the robotic platform. Moreover, the possibility to record in high definition en-

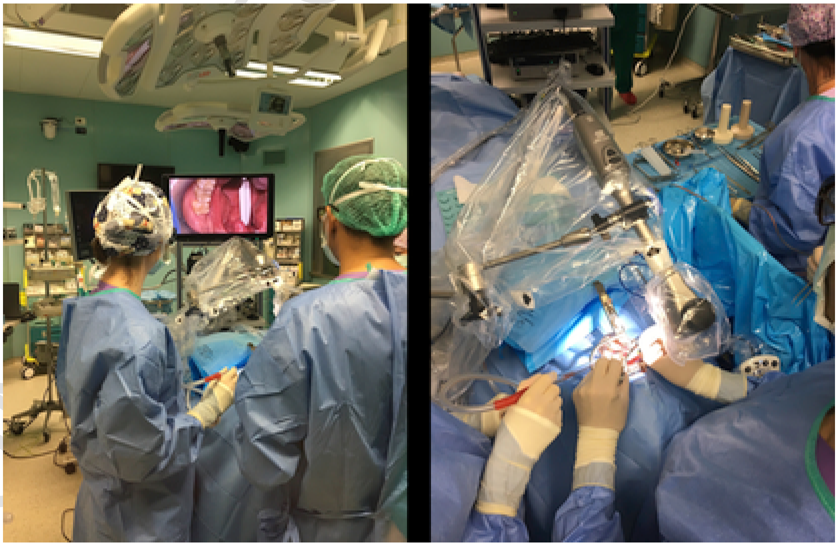

FIGURE 6.5

Operating room setting with VITOM in lateral pharyngoplasty surgical procedure.

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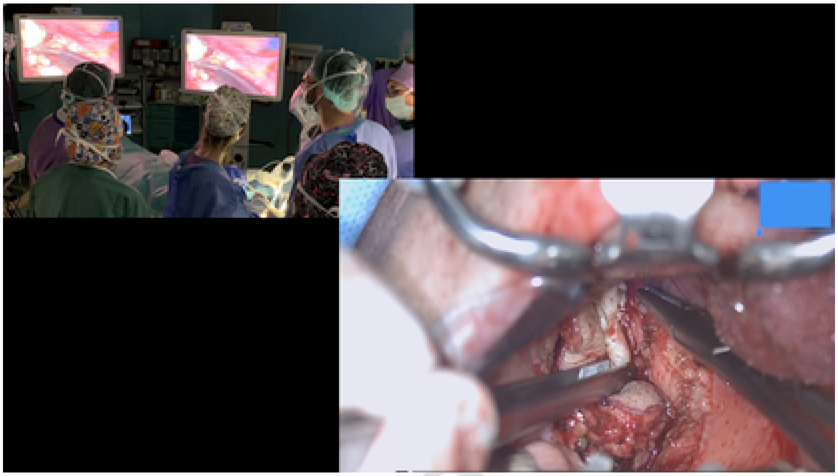

FIGURE 6.6

Operating room setting with VITOM inforearm free flap insetting and suturing.

FIGURE 6.7

Operating room setting with TIPCAM in endoscopic work-up for base of tongue squamous cell carcinoma (BOT SCC).

ables the surgeons to share videos for didactic sessions, meetings, and courses on surgical techniques.

At present, in a health policy aimed at reducing costs, it is difficult to have up-to-date technologies. The cost of the exoscopic platform is similar to that of an operating microscope with an electromagnetic brake holder and is about 10 times, lower than the Da Vinci robotic platform. The cost of disposable equipment for each surgical procedure is about 40–60 dollars, composed of two sterile sheaths for the holder and controller. Even the price of maintenance is considerably lower.

The current drawbacks can be represented by the mechanical holder that is not always comfortable to move during surgery, and the necessity to wear 3D glasses for a prolonged period that can lead to headaches and nasal pain (in only two patients out of 41 in our experience).

With the introduction of any new surgical approach, it is common to face difficulties achieving the optimum layout of the operating room, and the most favorable position for the exoscope/holder/camera control wheel (joystick) in the surgical field. However, the level of fine operativity achievable by TORS during dissection in the parapharyngeal space (retropharyngeal lymph node dissection) is not yet reachable by the 3Dees approach due to the absence of ad hoc designed surgical instruments, and the poor ergonomics when using the mechanical holder for VITOM.

6.5 Conclusions

The exoscopic approach using VITOM for oropharyngeal procedures can be considered an excellent alternative to the operating microscope and robotic surgery, with its excellent performance in visual translation, depth of field, magnification, image contrast and color. Purchase cost is reduced as VITOM is about 10 times less expensive than a Da Vinci robotic platform. The system is not bulky and the operator can use all conventional surgical instruments. Furthermore, when combined with HD video endoscopy, the system provides excellent visualization via the monitor, and if available, a 3D camera can also be used to enhance images. Thanks to this system, anatomic details are clearer, and fine vascularization and irregularities of the mucosa become perfectly visible. It provides ample working space and is extremely useful for training and educational purposes. This technique is extremely beneficial in the learning process, especially for residents, as it provides the same visual experience for all operators, and tutors can pilot the learners' surgical maneuvers.

The 3Dees approach can be added to the other established strategies for transoral resection of oropharyngeal squamous cell carcinoma and can also have immediate and straightforward application in non oncologic surgical procedures (tonsillectomy, lateral pharyngoplasty, etc.).

The exoscopic platform has been improved thanks to the development of 10 mm diameter 3D optics (0 –30 degrees) useful to treat those cancers in the tonsillar region toward the base of the tongue and vallecula.

Further research must be oriented to the development of an electromagnetic holder that makes the positioning of the exoscope quick, precise, and responsive.

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References

1. S. Elrefaey, et al., M A Massaro , S Chiocca. HPV in oropharyngeal cancer: the basics to know in clinical practice. Acta Otorhinolaryngol Ital. 2014;34(5):299–309.
2. E.M. Sturgis, K.K. Ang The epidemic of HPV-associated oropharyngeal cancer is here: is it time to change our treatment paradigms? J Natl Compr Canc Netw. 2011;9(6):665–673.
3. H.S. van Monsjou, et al., van Velthuysen ML, van den Brekel MW. Oropharyngeal squamous cell carcinoma: a unique disease on the rise? Oral Oncol. 2010;46(11):780–785.
4. K.L. Robinson, G.J. Macfarlane Oropharyngeal cancer incidence and mortality in Scotland: are rates still increasing? Oral Oncol. 2003;39(1):31–36.
5. N. Stransky, et al., Egloff AM, Tward AD. The mutational landscape of head and neck squamous cell carcinoma. Science. 2011;333(6046):1157–1160.
6. J. McKiernan, B. Thom CE: human papillomavirus-related oropharyngeal cancer: a review of nursing considerations. Am J Nurs. 2016;116(8):34–43.
7. P. Huet L'électro-coagulation dans les épithéliomas de l'amygdale palatine. Ann Otolaryngol. 1951;68:433–442.
8. C.H. Ryu, et al., Ryu J, Cho KH. Human papillomavirus-related cell cycle markers can predict survival outcomes following a transoral lateral oropharyngectomy for tonsillar squamous cell carcinoma. J Surg Oncol. 2014;110(4):393–399.
9. O. Laccourreye, et al., Hans S, Ménard M. Transoral lateral oropharyngectomy for squamous cell carcinoma of the tonsillar region: II. An analysis of the incidence, related variables, and consequences of local recurrence. Arch Otolaryngol Head Neck Surg. 2005;131(7):592–599.
10. O. Laccourreye, et al., Malinvaud D, Holostenco V. Value and limits of non-robotic transoral oropharyngectomy for local control of T1-2 invasive squamous cell carcinoma of the tonsillar fossa. Eur Ann Otorhinolaryngol Head Neck Dis. 2015;132(3):141–146.
11. W. Steiner, O. Fierek, P. Ambrosch, C.P. Hommerich, N. Kron Transoral laser microsurgery for squamous cell carcinoma of the base of the tongue. Arch Otolaryngol Head Neck Surg. 2003;129(1):36–43.
12. N.G. Hockstein, G.S. Weinstein, B.W. O'Malley Jr. Maintenance of hemostasis in transoral robotic surgery. ORL J Otorhinolaryngol Relat Spec. 2005;67(4):220–224.
13. N.G. Hockstein, et al., Nolan JP, O'Malley BW Jr. Robotic microlaryngeal surgery: a technical feasibility study using the daVinci surgical robot and an airway mannequin. Laryngoscope. 2005;115(5):780–785.
14. B.W. O'Malley Jr., et al., Weinstein GS, Snyder W. Transoral robotic surgery (TORS) for base of tongue neoplasms. Laryngoscope. 2006;116(8):1465–1472.
15. G.S. Weinstein, et al., O'Malley BW Jr, Snyder W. Transoral robotic surgery: radical tonsillectomy. Arch Otolaryngol Head Neck Surg. 2007;133(12):1220–1226.
16. E.J. Moore, M.L. Hinni Critical review: transoral laser microsurgery and robotic-assisted surgery for oropharynx cancer including human papillomavirus-related cancer. Int J Radiat Oncol Biol Phys. 2013;85(5):1163–1167.
17. E.M. Genden, S. Desai, C.K. Sung Transoral robotic surgery for the management of head and neck cancer: a preliminary experience. Head Neck. 2009;31(3):283–289. 20.
18. T.A. Iseli, et al., Kulbersh BD, Iseli CE. Functional outcomes after transoral robotic surgery for head and neck cancer. Otolaryngol Head Neck Surg. 2009;141(2):166–171.
19. E.J. Moore, K.D. Olsen, J.L. Kasperbauer Transoral robotic surgery for oropharyngeal squamous cell carcinoma: a prospective study of feasibility and functional outcomes. Laryngoscope. 2009;119(11):2156–2164.

UNCORRECTED PROOF

20. B.A. Boudreaux, et al., Rosenthal EL, Magnuson JS. Robot-assisted surgery for upper aerodigestive tract neoplasms. Arch Otolaryngol Head Neck Surg. 2009;135(4):397–401.
21. G.S. Weinstein, et al., O'Malley BW Jr, Magnuson JS. Transoral robotic surgery: a multicenter study to assess feasibility, safety, and surgical margins. Laryngoscope. 2012;122(8):1701–1707.
22. E.J. Moore, et al., Olsen SM, Laborde RR. Long-term functional and oncologic results of transoral robotic surgery for oropharyngeal squamous cell carcinoma. Mayo Clin Proc. 2012;87(3):219–225.
23. W.S. Kim, H.K. Byeon, Y.M. Park, et al. Therapeutic robot-assisted neck dissection via a retroauricular or modified facelift approach in head and neck cancer: a comparative study with conventional transcervical neck dissection. Head Neck. February 2015;37(2):249–254.
24. H.K. Byeon, F.C. Holsinger, D.H. Kim, et al. Feasibility of robot-assisted neck dissection followed by transoral robotic surgery. Br J Oral Maxillofac Surg. January 2015;53(1):68–73.
25. H.K. Goh, Y.H. Ng, D.T. Teo Minimally invasive surgery for head and neck cancer. Lancet Oncol. March 2010;11(3):281–286.
26. R.G. Blanco, K. Boahene Robotic-assisted skull base surgery: preclinical study. J Laparoendosc Adv Surg Tech A. 2013;23(9):776–782.
27. K.G. Krishnan, K. Scholler, E. Uhl Application of a compact high-definition exoscope for illumination and magnification in high-precision surgical procedures. World Neurosurg. 2017;97:652–660.
28. Z. Rossini, A. Cardia, D. Milani, G.B. Lasio, M. Fornari, V. D'Angelo VITOM3D: preliminary experience in cranial surgery. World Neurosurg. 2017;107:663–668.
29. L. Ricciardi, K.L. Chaichana, A. Cardia, et al. The exoscope in neurosurgery: an innovative "point of view". A systematic review of the technical, surgical, and educational aspects. World Neurosurg. 2019;124:136–144.
30. P.K. Frykman, et al., Frykman PK, Duel BP, Gangi A.. Evaluation of a video telescopic operating microscope (VITOM) for pediatric surgery and urology: a preliminary report. J Laparoendosc Adv Surg Tech A. 2013;23(7):639–643.
31. C. Carlucci, L. Fasanella, A. Ricci Maccarini Exolaryngoscopy: a new technique for laryngeal surgery. Acta Otorhinolaryngol Ital. 2012;32(5):326–328.
32. I. Tasca, G. Ceroni Compadretti, C. Romano High-definition video telescopic rhinoplasty. Acta Otorhinolaryngol Ital. 2016;36(6):496–498.
33. E. Crosetti, G. Arrigoni, A. Manca, A. Caracciolo, I. Bertotto, G. Succo 3D exoscopic surgery (3Des) for transoral oropharyngectomy. Front Oncol. January 31, 2020;10:16.

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