Robotic Devices in Head and Neck Surgery

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1 Platforms Available

1.1 da Vinci: Intuitive (Models Si, X, Xi, and SP)

The first platform to gain space in the market and remain a successful model in the specialty was the da Vinci robot, created with the objective of presenting good reproducibility, with an accreditation and security system for the use of the tool and thus standardize the procedures performed. It is a multiportal linear system that uses four articulated robotic arms and endoscopic cameras with 3D visualization, allowing the magnification of the image and high definition of the operative field. The surgeon remains on the console and has control of optics, movement and angulation of the tweezers, precision of movements, and ergonomics [1].

The latest model produced by the company, Single Port (SP), has the main advantage of keeping all devices coming out of the same portal and improving the mobility and angle of optics [2]. The SP has already been tested for use in robotic head and neck surgeries mainly in the USA and Asian countries but is not yet available in Brazil [3, 4].

At first, every head and neck surgeon who would like to obtain their certification as robotic surgeons had to perform their training and qualification in the USA. Since 2021, Brazil has the only center outside the USA where certification is provided in the specialty, through the postgraduate degree in robotic head and neck surgery of the private hospital [5].

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J. P. Manzano, L. M. Ferreira (eds.), *Robotic Surgery Devices in Surgical Specialties*, https://doi.org/10.1007/978-3-031-35102-0_7

1.2 Versius: Cambridge Medical Robotics

The system has as advantage the modular design with independent arms, facilitating the positioning of the robot for the onset of surgery (docking). The commands are also performed by the surgeon on the console [6]. There are no published reports related in the literature about use in head and neck surgeries.

1.3 Hugo: Medtronic

As well as Versius, Hugo is mobile and modular; it has four separate arms that can be relocated in the operating room as needed [7]. It is still underexplored in head and neck surgeries.

1.4 Flex Robotic System: Medrobotics

The Flex Robotic System is the first flexible system specifically designed for use in head and neck surgery, authorized by the FDA (Food and Drug Administration) for transoral surgeries. Consisting of a single arm for control the flexible endoscopic optic. The other tweezers attach to the mouth opener and the surgeon is close to the patient, handling the tweezers. This system is a device that is intended for robot-assisted visualization and surgical site access to the oropharynx, hypopharynx, and larynx in adults (≥ 22 years of age). Also provides accessory channels for compatible flexible instruments used in surgery [8].

2 Clinical Applications

2.1 Transoral Robotic Access TORS

Transoral robotic access is used for resection of lesions of the oropharynx (lingual tonsils, tonsillar tonsils, tongue base, soft palate), supraglottic larynx, hypopharynx, and parapharyngeal space [9]. The oropharynx is the main site affected with the greatest number of cases, that's why it will be highlighted in this chapter (Fig. 1).

Transoral robotic resection for early oropharynx tumors has established itself as a feasible and oncologically safe technique, being initially disseminated by Gregory Weinstein in 2010 at the University of Pennsylvania where he has also dedicated himself to certifying head and neck surgeons around the world to use the da Vinci robot [10] (Fig. 2).

The incidence of HPV-related oropharynx tumors has increased significantly in the last decade, mainly driven by white men, young adults with no history of

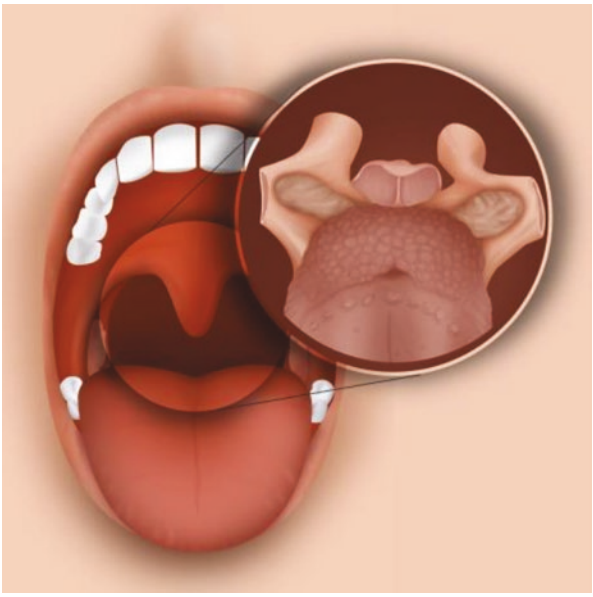

Fig. 1 Possible areas of transoral resection

Fig. 2 Early-stage tonsil cancer tonsil tumor exposure after mouth opener placement

smoking, according to US statistics [11]. Brazilian data from 2021 corroborate these data for our population, with the mean age of diagnosis being 59 years old [12]. Despite having a better prognosis when compared to tumors not related to HPV [11], at this time the same pattern of treatment can be performed exclusively with radiotherapy or surgery for initial tumors and chemotherapy concomitant with radiotherapy or surgical treatment, and for selected cases of locally advanced tumors there is the possibility of the use of neoadjuvant chemotherapy [13].

Surgical therapy for early tumors is safe and comparable with IMRT (intensity-modulated radiation therapy), while advanced tumors that have involved large surgical resections and association with adjuvant chemotherapy and radiotherapy should be avoided due to higher morbidity [13]. In this context, patients should be well selected for surgical treatment with adequate imaging and if possible magnetic resonance imaging to estimate the actual dimensions of the tumor, signs of vascular and bone damage, and lymph node extracapsular extravasation, and thus for treatment decision making. Recent studies question current treatments and the possibility of using robotic transoral surgery (TORS) also for advanced cases [14] (Fig. 3).

The scenario considered pandemic for HPV-related oropharynx tumors in young adult patients promotes the search for minimally invasive techniques, with lower morbidity and consequently less impact on the quality of life of patients who should remain with the sequelae resulting from treatment for a long period [14]. Patients with HPV-negative tumors, in the early stages, were also shown to be good

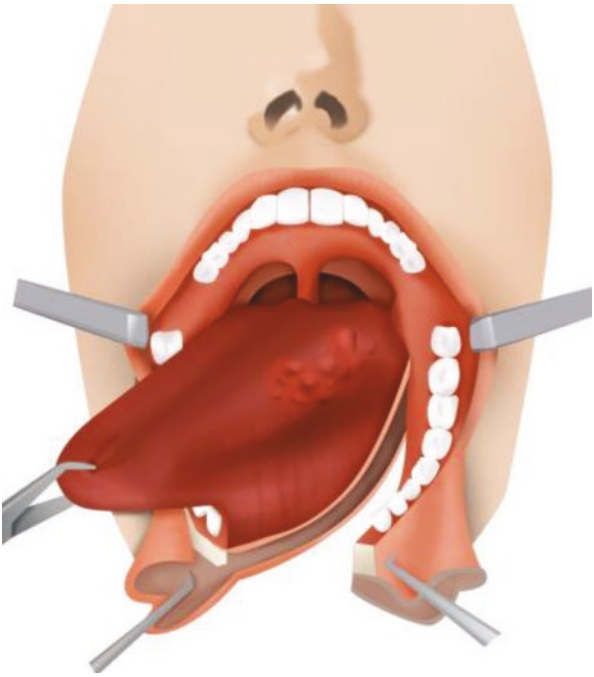

Fig. 3 Mandibulotomy for oropharyngeal tumor resection when there is no access to the robot

candidates for surgical treatment with adjuvant radiotherapy when compared to the treatment with upfront chemotherapy and radiotherapy [15].

Patients with cervical lymph node metastasis without primary site identified on physical examination or complementary tests such as PET-CT (occult primary) may be submitted to physical examination under narcosis with the use of a robot, having multiple biopsies performed. It is possible to proceed with resection with tonsillar tonsillectomy and ipsilateral lingual if necessary [16]. When locating the primary tumor, the therapy of choice is directed, which decreases the irradiated field and consequently the sequelae resulting from the treatment that, in this region, has implications in the rehabilitation of breathing, speech, and swallowing [17].

Hypopharynx and supraglottic larynx lesions are less frequent but also considered challenging because their structures are closely related to speech and swallowing. The consequences of the treatment, surgical or with radiotherapy/chemotherapy, can lead to severe dysfunctions requiring an alternative food route and tracheostomy [17]. Robotic transoral resection aims to provide a good oncological treatment with adequate margins with a better functional result, consequently improving the quality of life [17].

Using this same approach, it is also possible to treat benign pathologies such as resection of lingual tonsils for the treatment of sleep apnea and treatment of Eagle syndrome with removal of the styloid process [18]. Patients with tumors in the parapharyngeal space also benefit from transoral access [19]. Compared to conventional surgery that includes parotidectomy combined or not with access mandibulotomy, the use of TORS decreases the manipulation of complex regional neurovascular structures with potential for high complications such as facial paralysis and trismus [20]. It is noteworthy that the resection of parapharyngeal tumors requires high knowledge of local anatomy and familiarity with the use of the robotic platform, with its realization at the beginning of the learning curve not being indicated.

2.2 Vestibular Approach

Access to the anterior cervical region was standardized by Kocher, keeping in his honor the name of the cross-sectional incision, first described in 1912, being indicated for the surgical treatment of thyroid pathologies, parathyroid scans, and congenital malformations such as resection of thyroglossal cyst (Sistrunk surgery) [21]. This approach almost hasn't changed over the decades, but driven by the aesthetic and social appeal due the scar [21], remote access began to be studied.

The vestibular access, the space between the mucous part of the lower lip and the mandible, proved to be an alternative, being a discrete incision in the mucosa, not apparent in the anterior cervical region (Figs. 4, 5, and 6).

With this method, the surgeon makes a workspace (pocket) from the chin to the thyroid store with the use of laparoscopic material, insufflating carbon dioxide to form the workspace, and it can be performed with or without the robot's assistance.

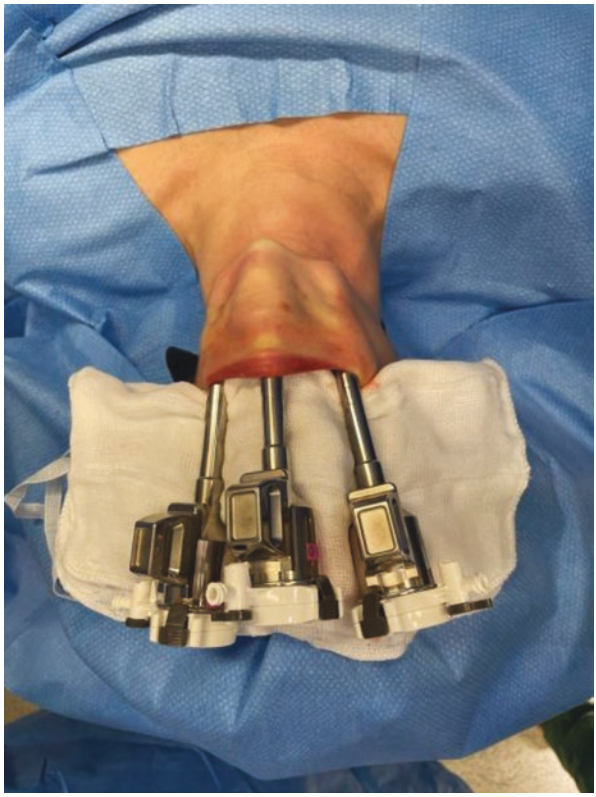

Fig. 4 View of the vestibular access with the trocars

Fig. 5 Vestibular incision after 30 days of surgery

The use of this approach makes it possible to perform partial or total thyroidectomies, parathyroidectomies, and neck dissection of level VI lymph nodes [22]. The main contraindications are related to the restricted space and operative field,

Fig. 6 Cervical aspect after 30 days of surgery

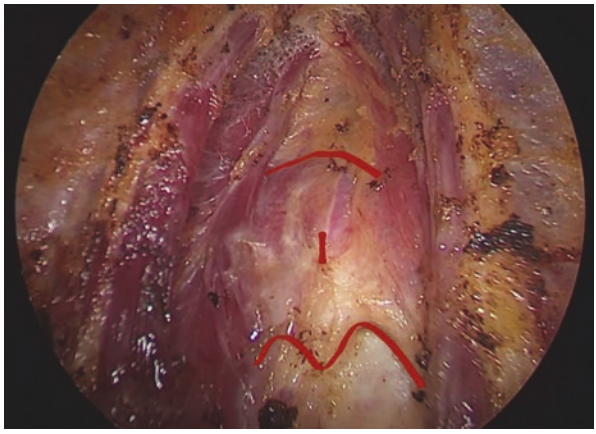

Fig. 7 Cavity after pocket done with thyroid isthmus visualization. *I* Isthmus

voluminous nodules, extensive tumors, and the presence of metastases to the lateral cervical lymph nodes, which limits the benefits of the technique and should be avoided [23].

Through the same access it is possible to perform thyroplasty to reduce thyroid cartilage for aesthetic purposes, in order to feminize the neck [24] (Fig. 7).

2.3 Skull and Nasopharynx Base

The main role of the robotic surgery in the treatment of skull base and nasopharynx tumors is in the resection of recurrent nasopharyngeal tumors, a surgery considered challenging due to the sequelae of previous treatment, difficulty in access, and limitation of the workspace [25].

Some combined endoscopic transnasal and transoral robotic approaches may facilitate tumor exposure and resection with adequate margins, as evidenced in various cases with good local disease control, 86% in 2 years [19].

2.4 Lateral Cervical Tumors

The most used remote access for cervical surgeries is the retroauricular access (Fig. 8), in which the jugulo-carotid space is accessed through the subplatysmal flap (Fig. 9). This approach allows the performance of thyroidectomies, mainly voluminous goiters that could not be resected by the transoral technique, as well as cervical emptying and resection of the salivary glands [26, 27] (Figs. 8 and 9).

Retroauricular access was initially used in video-assisted surgeries and later in robotic surgery, especially in Asian countries for patients with a propensity to develop hypertrophic or keloid scars [27]. Korean initial studies have observed good flap control for the treatment of benign or malignant pathologies of submandibular glands [28], which is a procedure considered rapid and important for the mastery of the technique and reduction of surgical time. Then, it was compared with the conventional technique with robotics, and no significant differences were found between the amount of resected lymph nodes and postoperative complications [29, 30], which at first would be the most feared divergences by the surgeons of the specialty. It was also carried out in Brazil almost a decade ago, demonstrating safety and reproducibility in Western countries and in our population (Fig. 10) [31, 32].

Fig. 8 Retroauricular incision

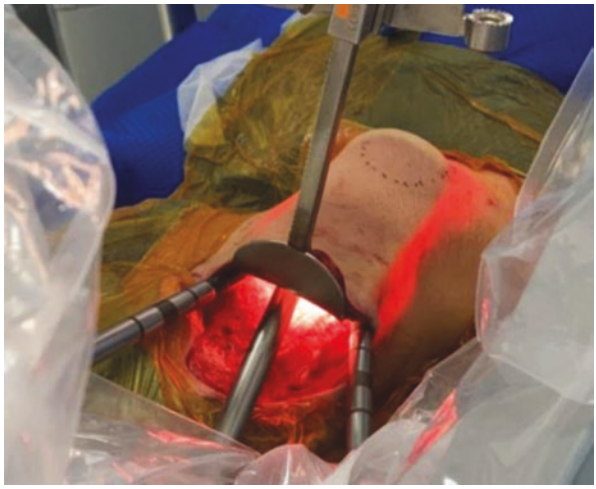

Fig. 9 Subplatysmal flap

Fig. 10 Cervical aspect after 30 days of right neck dissection surgery

Based on the experience of the robot use, it was possible to also apply it in the surgical treatment of pathologies of the parotid gland and delicate surgery due to manipulation of the facial nerve and its branches that permeate the gland.

The first robotic parotidectomies were performed in Asia in 2013 and 2014, and the experience was reported as successful [33, 34]. Using the retroauricular facelifting incision, it is possible to easily access the parotid store, associated with magnified three-dimensional visualization, dexterity gain, and surgical precision help in the identification and preservation of the facial nerve, the use of intraoperative nerve monitoring being maintained as in the conventional approach [35].

Since facial nerve paralysis was the most feared complication of parotidectomy, even when compared with groups of conventional surgery with video-assisted and robotic surgery, there was no difference in the incidence of permanent nerve injury and other complications, but it presented longer operative and hospital stay [36].

3 Limitations of Use

Among the limitations of the use of the robot are as follows: it can be punctuated by the need for specific training of techniques, mastery of oncological pathologies for precision in surgical indication, and certification with Intuitive, nowadays the holder of the right to use the da Vinci platform, the most used in the world. Not only should the medical team be prepared, but also the entire team in the operating room, before and after surgery, and they should conduct specialization and updating courses in the area.

Currently, Brazilian health insurances still do not cover their use due to the non-inclusion in the ANS List and should be funded exclusively by the patient. The cost of new technologies limits the spread of robot use, but this reality has been proven accessible as large hospitals have competitive values among themselves. The average cost for using the da Vinci Xi robot using two tweezers is 5000 reais.

4 Prospects for the Future

Several technology companies have launched their own robotic platforms, a promising and competitive scenario that favors price reduction and the dissemination of the tool among the specialty. There is a prospect of expansion in the proportion of surgeries with remote access to conventional ones and improvement of the use in parotidectomy and surgical treatment of paragangliomas [37].

The great innovation of Intuitive that favors our specialty is the Single-Port model, which provides in the same portal the tweezers and the camera, reducing the area necessary for dissection, but losing part of the grip strength in the tweezers. This model is still tied to high costs, being used in some reference hospitals and not yet available in Brazil. Some experiences show the use and possible benefits in lateral transoral and cervical surgeries [2, 3].

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