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HEAD AND NECK

Transoral robotic surgery for supraglottic cancer. A review of oncological and functional outcomes compared to open surgery

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SUMMARY

Objective. Supraglottic squamous cell carcinoma (SCC) represents a major surgical challenge in organ-preserving treatment. Type I open partial horizontal laryngectomy (OPHL I) is considered the most popular. To date, minimally-invasive approaches such as laser microsurgery and transoral robotic surgery (TORS) have gained increasing relevance. The aim of this narrative review is to obtain a descriptive comparison of functional and oncological outcomes from studies on patients with supraglottic SCC treated with OPHL I and TORS, respectively.

Material and methods. A computerised search was performed using the Pubmed database for articles published from 2000 to 2023. A comparative analysis on functional and oncological outcomes of patients treated by TORS and OPHL I was performed.

Results. The present narrative review shows a superiority of TORS compared to open surgery for supraglottic SCC in terms of functional outcomes, while maintaining comparable oncological outcomes.

Conclusions. Although recently introduced in the treatment of laryngeal pathology, TORS has been shown to be a reliable technique not only for functional but also for oncological outcomes, ensuring good overall survival, disease-free survival, and disease control rates comparable to OPHL I.

KEY WORDS: TORS, open supraglottic surgery, supraglottic carcinoma, OPHL

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Introduction

Laryngeal cancer is one of the most frequent tumours of the head and neck area and the most prevalent histotype is squamous cell carcinoma (SCC) [1]. Surgery is the mainstay for treatment of supraglottic SCC, although it depends on the characteristics of the tumour, stage and the patient's comorbidities. The most demanding challenge for this kind of surgery is to maximise oncologic outcomes, while ensuring an optimal functional outcome. Thanks to the growing search for less invasive surgical approaches, nowadays fewer patients are candidates for total laryngectomy in favour of open partial laryngectomy of the supraglottic region and minimally-invasive transoral techniques, which can be performed using transoral laser microsurgery (TOLMS) or a transoral robotic approach [2].

Open partial surgery was the first organ-preserving therapeutic strategy used in the treatment of supraglottic tumours of the larynx. Succo et al. developed the most recent classification of reconstructive surgical approaches, specifically naming Type I Open Partial Horizontal Laryngectomy (OPHL I) that applied to the treatment of supraglottic carcinoma [3]. Nowadays, conservative surgical indications in the treatment of supraglottic SCC include all patients with early (T1 and T2) and intermediate (T3) categories of disease [4]. However, this type of surgery is con-

traindicated in patients over 70 years of age with neurological, cardiac, pulmonary and metabolic comorbidities as they could hamper adequate post-surgical functional recovery [4].

On the other hand, TORS is becoming an increasingly reliable option to approach supraglottic tumours of the larynx. The indications for robotic surgery are tumours staged as cT1, cT2 and cT3 (TNM classification VIII ed.), with or without lymph node metastasis that require simultaneous or delayed neck dissection [5,6]. However, presence of nodal disease has a negative impact on prognosis and oncological outcomes [7]. Contraindications to TORS are: poor transoral exposure (inter-incisor distance < 3 cm, trismus, macroglossia), invasion of the thyroid and/or cricoid cartilage, fixation of one vocal fold and/or arytenoid, invasion of the inferior paraglottic space, posterior commissure, deep infiltration of the base of tongue and lingual extrinsic muscles [6].

Thanks to the continuous technological improvements over the years, TORS has become increasingly important in the international surgical landscape. The introduction of dedicated retractors, such as the FK (Gyrus Medical Inc., Maple Grove, MN, USA), allowed the epiglottis to be adequately exposed, ensuring optimal visualisation of the larynx [8]. The use of innovative optics and screens, based on high-definition three-dimensional (HD-3D) technology, provides a higher resolution and magnification power than any other type of surgical technique [9]. Technological advances in robotic instrumentation have also attempted to reduce the problem of encumbrance by endoscopic and operating arms, moving from the Da Vinci Si robot® HD (Intuitive Surgical, Sunnyvale, CA, USA), characterised by rigid arms, to the hybrid system consisting of a flexible endoscopic arm and other flexible operative arms, the Flex robot® Robotic System (Medrobotics, Raynham, MA, USA). Barbara et al. [10] compared the technical and operative potential of the two types of robots. As advantages of the Flex robot, they reported a shorter set-up time, better haptic feedback, and a higher manageability. Accordingly, flexible microinstruments have a force and grip that allow space to be made between tissues to reach the surgical targets and inspect anatomical structures such as the piriform sinus.

Recently, a further technological development has been the introduction of the Da Vinci Sp® HD-3D (Intuitive Surgical, Sunnyvale, CA, USA), based on a single 25-mm diameter arm from which further 6-mm endoscopic and rigid arms branch off with a 360° movement capability in the operating field. Sampieri et al. [11] reported their experience comparing intra- and postoperative outcomes, technical advantages, and shortcomings of transoral laryngeal and hypopharyngeal resections performed with the Da Vinci Sp® HD-3D (Intuitive Surgical, Sunnyvale, CA, USA) and the Da Vinci Si/Xi systems. The safety profile of the Da Vinci Sp® HD-3D can be considered comparable to that of previous models, while it showed advantages in terms of reduced docking times. Console times were also shortened due to improved manoeuverability and field visualisation. No significant difference emerged from the analysis of the duration of hospitalisation, enteral feeding, and TORS-related complications.

The aim of this narrative review was to compare the main functional and oncological outcomes of publications describing case series treated by TORS with those applying an OPHL technique. Reports with cohorts of patients affected by supraglottic SCC reporting both functional and oncological outcomes were selected.

Materials and methods

Search strategy and information sources

A computerised search was performed using Pubmed for articles published from 2000 to 2023.

Study selection and data extraction

After running the search in December 2023, abstracts and titles obtained were screened independently by two of the authors (FC and PG), who subsequently met and discussed disagreements on citation inclusion. Inclusion criteria for abstract selection were English language and subjects affected by supraglottic SCC treated with TORS or OPHL I. We excluded studies with no abstract, or adopting languages other than English, or not describing any information about supraglottic SCC treated with TORS or OPHL I. The same authors screened the full texts identified by such criteria, and then met and discussed disagreements on article inclusion. Inclusion and exclusion criteria for full-text selected articles were the same as the above described for abstract selection. Information from each study was extracted using a standardised data extraction form.

Data analysis

Patient data were extracted and summarised. Categorical variables were presented as frequency and percentage. Continuous variables were presented as mean and range. The statistical analyses were carried out with STATA v.14 (StataCorp LLC, College Station, TX, USA).

Results

Twenty-four publications (9 on TORS and 15 on OPHL I) were included in this review. The papers were published between 2000 and 2023. The total number of patients included was 893 (266 for TORS and 627 for OPHL I). The largest study population consisted in 116 patients.

Functional outcomes

Concerning post-surgical functional outcomes, data on

Table I. Functional outcomes after TORS for supraglottic SCC.

Author (year)	No. of cases	Length of hospital stay (days)	Tracheotomy	Time of decannulation (days)	Feeding tube	Time of removal (days)	PEG	Swallowing outcomes
Weinstein (2007) [14]	3	5.3	0 (0%)	NA	0 (0%)	NA	0	Return to swallowing 5.3 weeks after surgery
Ozer (2012) [16]	13	3.9	1 (8%)	17	1 (8%)	NA	0	All patients able to eat an oral diet 1 day after surgery
Mendelsohn (2012) [20]	14	11	0 (0%)	NA	NA	NA	0	4.5 days for safe swallowing of solids; 5.5 days for safe swallowing of thin liquids
Olsen (2013) [16]	9	NA	7 (78%)	NA	4 (45%)	NA	0	NA
Ansarin (2013) [17]	10	13	9 (90%)	NA	7 (70%)	12	1 (10%)	NA
Oysu (2013) [25]	3	NA	NA	NA	3 (100%)	8.3	0	NA
Park (2013) [12]	16	18.6	16 (100%)	9.2	16 (100%)	8.3	0	NA
Razafindranaly (2015) [18]	84	15.1	20 (24%)	8	64 (76%)	8	8 (10%)	20 patients (24%) able to eat an oral diet 1 day after surgery
Slama (2016) [26]	22	NA	NA	NA	22 (100%)	NA	NA	NA
Karabulut (2018) [15]	17	8.8	0 (0%)	NA	17 (100%)	7	0	NA
Hans (2020) [27]	75	6.8	6 (8%)	NA	8 (11%)	NA	0	NA

NA: not available; PEG: percutaneous endoscopic gastrostomy.

hospitalisation time, need for tracheotomy, placement of a nasogastric tube (NGT), percutaneous endoscopic gastrostomy (PEG) and modality and recovery of swallowing were compared. Table I shows data on the functional results achieved by patients undergoing TORS, while Table II shows data on patients treated with OPHL I.

Length of hospitalisation

Hospitalisation length was reported in 8 articles on treatment of supraglottic SCC by TORS, and ranged from 3.9 to 18.9 days (mean, 10). Nine articles reported the length of stay on patients treated with OPHL I, with a range between 5 and 104 days (mean, 31.3).

Tracheotomy

Altogether, 59 of 241 patients (24%) treated with TORS underwent tracheotomy. All patients treated with OPHL had undergone a temporary tracheotomy. Tracheotomies performed postoperatively due to surgical complications (4 cases) were excluded from the analysis. The decannulation time of patients undergoing TORS and OPHL I was 11 and 40 days, respectively.

Nasogastric tube

This review shows that a NGT was placed in 147 of 252 patients (58%) treated with TORS. In contrast, all patients undergoing OPHL I underwent NGT placement. The NGT was removed after 9 and 36 days, respectively, in patients undergoing TORS and OPHL I. NGT removal time in patients undergoing OPHL I was extremely heterogeneous, varying from 8 to 80 days.

Gastrostomy

PEG was less frequently required in patients undergoing TORS with a maximum of 10% of patients. Indeed, the same procedure was adopted in a higher percentage of patients treated by OPHL, with a range of 0-29%.

Swallowing

There were no parameters about swallowing that allow a satisfactory comparison between the outcomes of patients undergoing TORS and OPHL I.

Oncological outcomes

Nine studies on patients treated with TORS (Tab. III) and 9 on patients treated by OPHL I (Tab. IV) were selected to analyse oncological outcomes, in particular overall survival (OS) and disease-free survival (DFS), as well as local and regional control rates.

Overall survival

In patients treated by TORS, OS ranged from 66.7% at 26 months to 100% at 25 months. After OPHL I, OS ranged from 61% to 90% at 5-year follow-up.

Table II. Functional outcomes after OPHL I.

Author (year)	No. of cases	Length of hospital stay (days)	Rate of decannulation	Time of decannulation (days)	Time of removal of feeding tube (days)	PEG	Swallowing function outcomes
Bron (2000) [24]	69	35	100%	27	30	0	NA
Bussi (2000) [28]	44	30.5	97.7%	91	16	0	93.2% of patients satisfactory deglutition
Karasalihoglu (2004) [29]	68	NA	100%	27.7	26.4	0	99% of patients were able to swallow
Lewin (2008) [30]	27	7.7	NA	37	9.4	NA	Supraglottic swallow manoeuvre was effective in 57% of patients
Nakayama (2007) [13]	32	104	100%	15	NA	NA	90% of patients achieved the ability to eat
Saito (2009) [21]	24	NA	95.8%	52	38	NA	Mean postoperative time before the start of oral diet was 16.6 days
Goncalves (2010) [31]	20	5	90%	105	71	0	NA
Webster (2011) [22]	10	NA	NA	NA	82	0	0% of patients tolerated thin liquid within 3 weeks, 67% within 6 months, and 80% within 1 year
Park (2011) [12]	116	43.2	NA	20	26.4	0	NA
Topaloglu (2011) [32]	30	NA	100%	23.6	27.3	0	Few patients with premature intra-deglutition spillage; on average satisfactory swallowing ability
Clayburgh (2012) [33]	18	7.3	100%	27.4	88	0	67% unrestricted diet
Karabulut (2018) [15]	20	14.7	100%	34.7	7	0	NA
Mesolella (2020) [34]	36	NA	98%	23.4	21.8	0	NA
Gokmen (2020) [19]	31	25.7	74%	44.7	36.6	9 (29%)	NA

NA: not available; PEG: percutaneous endoscopic gastrostomy.

Disease-free survival

Patients treated by TORS presented a range of DFS between 87.6% and 100% at 26 months of follow-up. Among patients undergoing OPHL I, disease-specific survival (DSS) ranged between 72.1% and 95% at 5-year follow-up.

Local and regional control of disease

The group of patients treated by TORS was characterised by a local control of disease at 2- and 5-year follow-up of 100% and 90%, respectively. Indeed, the group of patients treated by OPHL I presented a local control of disease of 85% at 5-year follow-up. The regional control rate of patients treated by TORS was 87.5% at 26 months and 100% at 24 months. In patients treated by OPHL I the regional control rate was 85% at 5 years.

Discussion

According to this review, hospitalisation time was approximately 3 times shorter after TORS than after OPHL I, which is somewhat in contrast with the literature. Park et al. [12] compared the average hospitalisation length of 17 patients with supraglottic SCC operated by TORS with that of 17 patients undergoing OPHL I, obtaining mean hospitali-

Table III. Oncological outcomes after TORS for supraglottic SCC.

Author (year)	No. of cases	T1	T2	T3	T4	N0	N+	R+	Adjuvant RT or CH or CH-RT	Mean FU time (months)	OS (months)	DSS/DFS (months)	Local control (months)	Regional control (months)	Distant control (months)
Olsen (2012) [35]	9	0	5	3	1	4	5	0	6 (67%)	26	66.7% (26m)	87.5% (26m)	100% (26m)	87.5% (26m)	100% (26m)
Mendelsohn (2012) [20]	14	NA	NA	NA	NA	NA	NA	0	10 (71%)	28	88.9% (24m)	100% (24m)	NA	NA	NA
Ansarin (2013) [17]	10	4	4	1	1	6	4	4	7 (70%)	25	100% (25m)	100% (25m)	100% (25m)	90% (25m)	100% (25m)
Oysu (2013) [25]	3	3	0	0	0	3	0	0	2 (67%)	14	100% (14m)	100% (14m)	100% (14m)	100% (14m)	100% (14m)
Park (2013) [12]	16	7	6	4	0	NA	NA	0	8 (50%)	16	91% (16m)	NA	NA	NA	NA
Razafindranaly (2015) [18]	84	29	46	9	0	54	30	8	63 (75%)	14	98% (14m)	98% (14m)	98% (14m)	NA	NA
Karabulut (2018) [15]	17	5	4	8	0	NA	NA	0	13 (76%)	25	88% (25m)	94% (24m)	NA	NA	NA
Doazan (2018) [23]	122	44	62	16	0	62	60	8	63 (52%)	60	86.9% (24m) 78.7% (60m)	95.1% (24m) 94.3% (60m)	94.3% (24m) 90.2% (60m)	91.8% (24m) 87.7% (60m)	NA
Hans (2020) [27]	75	23	40	5	0	41	34	4	26 (35%)	60	80.2% (60m)	94.3% (60m)	93.2% (60m)	89.2% (60m)	NA

NA: not available; RT: radiotherapy; CH: chemotherapy; FU: follow-up; OS: overall survival; DSS: disease-specific survival; DFS: disease-free survival.

Table IV. Oncological outcomes after OPHL type I.

Author (year)	No. of cases	T1	T2	T3	T4	N0	N+	R+	Adjuvant RT or CH or CH-RT	Mean FU time (months)	OS (years)	DSS/ DFS (years)	Local control (months, years)	Regional control (years)
Bron (2000) [24]	69	20	40	9	5	60	9	8	11 (16%)	NA	66.5% (5y)	80.1% (5y)	84% (5y)	NA
Karasalihoglu (2004) [29]	68	8	45	10	5	60	8	NA	1 (2%)	62	78.6% (5y)	93.9% (5y)	89.5% (5y)	90.4% (5y)
Nakayama (2007) [13]	32	2	12	16	2	28	4	NA	NA	28	61% (5y)	NA	100% (28m)	NA
Goncalves (2010) [31]	20	1	5	12	2	18	2	0	6 (30%)	25	90% (5y)	85% (5y)	NA	NA
Park (2011) [12]	116	NA	NA	NA	NA	97	19	5	24 (21%)	NA	66.6% (5y)	72.1% (5y)	88.7% (5y)	85% (5y)
Topaloglu (2012) [32]	30	0	13	17	0	4	26	NA	8 (27%)	56.2	NA	NA	NA	NA
Karabulut (2018) [15]	20	4	6	10	0	NA	NA	NA	15 (75%)	41	95% (5y)	95% (5y)	NA	NA
Mesolella (2020) [34]	35	0	9	21	5	29	6	NA	NA	51,4	83% (5y)	76.3% (5y)	NA	NA
Gokmen (2020) [19]	31	NA	NA	NA	NA	NA	NA	NA	NA	66	83.9% (5y)	80.6% (5y)	NA	NA

NA: not available; RT: radiotherapy; CH: chemotherapy; FU: follow-up; OS: overall survival; DSS: disease-specific survival; DFS: disease-free survival.

sation lengths of 18.6 and 24.9 days, respectively. Possible explanations for this result include the fact that Nakayama et al. [13] hospitalised their patients for an average of four months after OPHL I, which is significantly longer and in contrast with the other studies reported in Table II. However, it can be deduced from the literature that the hospitalisation length is systematically shorter in patients treated with TORS.

Currently, there is no consensus about the indication for temporary tracheotomy during TORS. Some authors do not routinely perform it [14,15], others only in selected cases [14-16], and still others in almost all[17] or all treated patients [14]. Only 24% of patients treated with TORS had undergone a temporary tracheotomy. In contrast, intraoperative tracheotomy was performed in all patients treated with OPHL I. It is important to emphasise that the weaning rate from tracheotomy was close to 100% of treated patients, except in some studies where it was 86-92% [18-24]. The decannulation time of patients undergoing OPHL I is 3 times longer compared to TORS, while the techniques were associated with similar lengths of hospitalisation.

Just as with tracheotomy, the positioning of NGT is not uniform after treatment with TORS. Some authors do not consider its positioning during the procedure to be appropriate [14], while others place it in all patients [16]. At the same time, the use of a temporary gastrostomy was dissimilar among patients treated by TORS or OPHL I. For the former technique, the use of gastrostomy is not widespread. Only Ansarin et al. [17] and Razafindranaly et al. [18] reported its placement in about 10% of patients in their case series. This is in contrast with some authors reporting patients treated by OPHL I. Gokmen et al. [19] reported that 29% of patients underwent placement of this device.

The swallowing outcome was not described using same parameters in patients treated by TORS and OPHL I. However, as shown in Table III, Weinstein et al. [14] described a return to full nutrition on average at 5.3 weeks after surgery in their case series. Ozer et al. [16] reported that all patients restarted oral feeding, and 20% of the patients reported by Razafindranaly et al. [18] did it one day after the procedure. Mendelsohn et al. [20] stratified the recovery of solid and liquid food feeding in their series as 4.5 and 5.5 days after surgery, respectively. More than 90% of patients who underwent OPHL I regularly restarted feeding after the surgical procedure [13,21]. Saito et al. [21] pointed out that the onset of oral swallowing occurred at an average of 16.7 days onwards, which is significantly longer than the time by Ozer et al. after TORS [16]. Finally, Webster et al. [22] stratified the percentage of patients who were able to swallow fluids without fatigue after 3 weeks, 6 months, and 1 year in 0%, 67%, and 80%, respectively.

Oncological outcomes are almost overlapping between TORS and OPHL I. Doazan et al. [23] reported 2- and 5-year OS of 86.9% and 78.7%, respectively. In OPHL I, OS ranged from 61% [13] to 90% at 5-year follow-up [16]. Similarly, DFS was comparable between the two types of surgeries. Doazan et al. [23] reported 2- and 5-year DFS of 95.1% and 94.3%, respectively. In contrast, among patients undergoing TORS, DSS ranged from 72.1% [16] to 95% at 5-year follow-up [15]. The local control of disease in TORS had satisfactory values, and was achieved in > 90% in all the studies included, as reported in Table III. At 2-year follow-up, the value was close to 100% [17]. At 5-year follow-up, it was still > 90% [15]. In OPHL I (Tab. IV) these values were slightly lower, as can be seen in the cohort of Bron et al. [24] in which the mean value reported was 84% at 5 year. For what concerns regional control with TORS, the values were also reasonably high and ranged from 87.5% at 26 months [16] to 100% at 24 months [19]. As far as regional control is concerned, the average reported in OPHL I is around 85% at 5 years [16].

The heterogeneous distribution in terms of staging of the different case series analysed represents the most important drawback of this review. To limit this bias as much as possible, only studies containing data from patients with both early and intermediate stages of disease were included, excluding those with unbalanced case histories in favour of early or advanced stages of disease. Another limitation concerns the heterogeneity of follow-up, which is more evident in the studies on robotic surgery. More specifically, as can be seen in Table III, many publications on TORS presented data with an average follow-up of about 2 years, which does not allow for the calculation of 5-year OS and DFS (Tab. IV).

Conclusions

Organ-preserving surgery is assuming an increasingly important role in the treatment of supraglottic SCC. TORS is proving to be an excellent alternative to OPHL I. While providing comparable results in terms of oncological outcomes, there is a clear imbalance in favour of TORS in terms of functional ones. Thanks to the progressive availability of increasingly better robotic technologies and the consequent advances in interventional methodologies, these advantages appear likely to further increase in both the short and medium term.

Conflict of interest statement

The authors declare no conflict of interest.

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Author contributions

FC, PD, PG: conceived of the presented idea and designed the study; FC: contributed to the data collection, to the analysis of the results and to the writing of the manuscript, with the support of PG. All authors reviewed the results and approved the final version of the manuscript.

Ethical consideration

The research was conducted ethically, with all study proce-

dures being performed in accordance with the requirements of the World Medical Association's Declaration of Helsinki. Written informed consent was obtained from each participant/patient for study participation and data publication.

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