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Voice and communication after open partial horizontal laryngectomies: A cross-sectional outcome study

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Abstract

Objective: The present study evaluates voice and communication after open partial horizontal laryngectomies (OPHLs), according to surgery and patient-related variables.

Methods: Fifty-eight patients were included: 18 type I OPHL, 20 type II OPHL and 20 type III OPHL. Acoustic, aerodynamic, endoscopic, perceptual and self-assessment analyses were carried out. Surgery-related variables and patient-related variables were considered for the analysis.

Results: Type I OPHL revealed the best phonatory outcomes. Type II and type III OPHL showed similar and poor results, with a highly deteriorated voice quality. A significant difference in MTP was found for patients who had both arytenoids/cricoarytenoid units preserved. Age and time from surgery showed significant correlations with voice quality after OPHLs.

Conclusions: Voice and communication outcomes after OPHLs are heterogeneous and might be influenced by several factors. Knowing variables with a substantial impact on phonatory outcomes may help clinicians in the preoperative decision-making process and the postoperative rehabilitative program.

KEYWORDS
communication, laryngeal cancer, laryngectomy, voice

1 | INTRODUCTION

Open partial horizontal laryngectomies (OPHLs) represent a system of modular function sparing surgical approaches to treat early-intermediate laryngeal carcinomas.

According to the OPHL classification system proposed by Succo et al.,[1] three types of open partial horizontal laryngectomies can be described based on the lower limit of resection: type I (supraglottic laryngectomy), type II (supracricoid laryngectomy), and type III (supratracheal laryngectomy). Moreover, each type of OPHL can be extended to adjacent anatomical structures. In such cases, the extension of surgical resection is indicated as +ARY (extension to one arytenoid); +CAU (extension to one crico-arytenoid unit, composed of the arytenoid, the crico-arytenoid joint and the underlying hemicricoid plate); +BOT (extension to the base of tongue); +PYR (extension to one piriform sinus). Concerning type II and III OPHL, a further distinction can be made based on whether the suprahyoid part of the epiglottis is spared (type IIa OPHL with crico-hyoido-epiglottopexy and type IIIa OPHL with tracheo-hyoido-epiglottopexy) or not (type IIb OPHL with crico-hyoidopexy and type IIIb OPHL with tracheo-hyoidopexy). Type I OPHLs spare the glottic plane, while both type II and type III OPHLs sacrifice the vocal folds, requiring the creation of a neoglottis.

As function sparing open surgical approaches, OPHLs aim at restoring the principal laryngeal functions (breathing, swallowing and phonation) without a permanent tracheostoma, with a positive impact on the patient's quality of life.[2–4] Oncological and functional results after OPHLs have been widely investigated, obtaining excellent overall survival, disease-free survival and laryngectomy-free survival rates.[5–8] Concerning 5 years laryngeal function preservation rates, type II and III OPHL showed similar results, varying from 91.2% to 98.5% according to the extension of the disease.[5,6] Despite excellent laryngeal function preservation rates, voice quality can be deeply affected after OPHLs, especially after supracricoid and supratracheal resections, where vocal folds are not spared. Voice after type II and type III OPHLs is usually similarly deteriorated, with a hoarse and breathy quality, as shown by Schindler et al.[9,10] Conversely, vocal folds are spared in type I OPHLs, with better voice quality outcomes.[11,12] While several studies have been carried out to describe overall functional results of open partial laryngectomies, still few data are available specifically regarding a systematic and comparative analysis of voice and communication outcomes after type I, type II, and type III OPHLs.

The present study aims to examine voice and communication outcomes after type I, type II and type III OPHLs. The authors hypothesize that voice and communication outcomes might be variably affected both by surgery-related variables (type of OPHL resection; number of ARY/CAU preservation; epiglottis preservation) and by patient-related variables (age, time from surgery, education, job).

2 | MATERIALS AND METHODS

The present cross-sectional outcome study was carried out according to the Declaration of Helsinki and it was previously approved by the Institutional Review Board. All subjects enrolled in the study gave their written informed consent; all data were collected retrospectively.

2.1 | Patients

Patients were selected from a database of 1081 patients who underwent OPHL at the Department of Otolaryngology of the Martini Hospital of Turin, the FPO-IRCCs Candiolo Cancer Center and the Vittorio Veneto Civil Hospital.

Selection criteria were previous OPHL, no evidence of disease and laryngeal function preservation at the last follow-up (preservation of respiration, speech and oral feeding without percutaneous endoscopic gastrostomy or nasogastric tube, absence of tracheostoma, no salvage total laryngectomy performed), no preoperative or postoperative radiochemotherapy, and >4 months after surgery. All patients underwent the same preoperative and postoperative course as described by Rizzotto et al.[13] In particular, each patient underwent standard voice and speech rehabilitation during hospitalization, consisting of a supraglottic voice training aiming at a basic understanding and activation of the neoglottis. It focuses on apnea training, push-pull exercises and short vocalizations with hard onsets. No further rehabilitation was provided.

Patients from the database were screened for the inclusion criteria and stratified according to the OPHL type. A unique identification number was assigned to each subject, and 20 patients for each OPHL type were selected. Instrumental and/or audio files were missing for two patients who underwent type I OPHL. Hence a total of 58 subjects were included in the present study: 18 patients who underwent type I OPHL, 20 patients who underwent type II OPHL and 20 patients who underwent type III OPHL.

Sociodemographic and clinical features of the sample (sex, education degree, job, pT status, pN status, OPHL type, neck dissection) are shown in Table 1. Mean age was 62 ± 9 years and mean time from surgery to the last functional assessment was 42 ± 37 months.

2.2 | Voice assessments

Patients' voices were recorded in standard conditions with a Samson Meteor Mic (Samson Technologies, Hauppauge, NY) placed at 30 cm from the mouth of the patient in a quiet environment (<40 dB), connected via USB to a MacBook Pro computer (Apple, Cupertino, CA) running PRAAT software (Version 5.3.57 for Mac, Boersma & Weenick, University of Amsterdam, Amsterdam, the Netherlands). The audio signals were digitized on 16 bit at a sampling frequency of 48 kHz.

Maximum phonation time (MPT) was measured through the window selection of the longest of three sustained /a/. Spectrograms of the sustained vowel /a/ were

TABLE 1 Frequency distribution of socio-demographic, clinical, and treatment characteristics of the patients' sample

Variable	N (%)
Gender	
M	52/58 (89.7%)
F	6/58 (10.3%)
Education degree	
Primary school	14/58 (24.1%)
High school/bachelor	44/58 (75.9%)
Job	
Employed	21/58 (36.2%)
Unemployed/retired	37/58 (63.8%)
pT status	
1	8/58 (13.8%)
2	23/58 (39.7%)
3	22/58 (37.9%)
4	5/58 (8.6%)
pN status	
0	44/58 (75.9%)
1	8/58 (13.8%)
2	1/58 (1.7%)
3	0/58 (0.0%)
x	5/58 (8.6%)
OPHL type	
I	10/58 (17.2%)
I + ARY	3/58 (5.2%)
I + BOT	4/58 (6.9%)
I + PYR	1/58 (1.7%)
IIa	6/58 (10.4%)
IIa + ARY	12/58 (20.7%)
IIb	1/58 (1.7%)
IIb + ARY	1/58 (1.7%)
IIIa	6/58 (10.4%)
IIIa + CAU	9/58 (15.5%)
IIIb	0/58 (0.0%)
IIIb + CAU	5/58 (8.6%)
ND	
Yes	50/58 (86.2%)
No	8/58 (13.8%)

performed with a frequency range of 0–5000 Hz and calculated with a 0.05 s window length and a 45 dB dynamic range.

According to the proposed modified Titze's classification, patients' voices were classified into four categories based on the spectrographic analysis.[14] The following categories were used: (1) type 1 voices, periodic without strong modulations or subharmonics; (2) type 2 voices, with strong modulations, bifurcations, or subharmonics; (3) type 3 voices, smearing of energy across harmonics with visible fundamental frequency and 1 or 2 harmonics; (4) type 4 voices, aperiodic.

Perceptual assessments were carried out with the INFVo rating scale, a perceptual scale specifically developed for substitution voice, assessing overall quality impression and intelligibility (I), additive and unnecessary noise (N), speech fluency (F), and presence of voiced segments (Vo).[15,16] Each parameter is scored on a visual analogue scale from 0 (minimally deviant) to 10 (maximally deviant substitution voicing). The perceptual evaluation was performed by listening to a recorded 56-word and 99-syllable passage. All voice recordings were assessed independently by two raters blinded to the study, speech and language pathologists with more than 10 years of experience, who underwent a specific training. In case of disagreement between the raters, they jointly reassessed the parameter until a consensus was reached. Since a final common scoring outcome was obtained for all perceptual parameters, no inter- and intra-rater reliability analysis were conducted.

2.3 | Videolaryngoscopies

Endoscopies were conducted with an Olympus Evis Exera II 18 endoscopy system and an Olympus ENF VQ trans-nasal flexible endoscope (Olympus Corporation, Tokyo, Japan) and were video recorded.

The patients were asked to produce the following phonatory tasks: a sustained /i/, a low-pitched /i/, a high-pitched /i/, a low-intensity /i/, and a high-intensity /i/. The following variables were assessed: (1) vibratory characteristics of the neoglottis, (2) degree of arytenoids motion, and (3) sphincteric closure of the larynx. Each variable was scored by an experienced phoniatrician, blinded to the study, on a 5-point rating scale from 1 (poor performance) to 5 (excellent ability), as suggested by Zacharek et al.[17]

2.4 | Communication-related quality of life

Each patient completed the Italian version of the Self-Evaluation of Communication Experiences after Laryngeal Cancer (I-SECEL).[18,19] The I-SECEL is a reliable and validated questionnaire assessing explicitly the impact of communication dysfunction on daily activities in patients who underwent laryngectomy. The questionnaire is made up of 34 items divided into three subscales: General (5 items), Environmental (14 items), and Attitudinal (15 items). Scores range 0–102 for the total score, 0–15 for the general subscale, 0–42 for the environmental subscale, and 0–45 for the attitudinal subscale. The higher the score, the greater the perception of communication dysfunction.

2.5 | Statistical analysis

Statistical analysis was carried out with GraphPad Prism software Ver 7.0 (GraphPad Software, San Diego, CA). Means and standard deviations (SDs) for continuous variables were calculated. The normality of the distributions was assessed with the D'Agostino Pearson test.

Voice and communication outcomes variables were compared according to both surgery-related and patient-related variables. The considered surgery-related variables were type of OPHL resection (I vs. II vs. III); the number of ARYs/CAUs preserved (1 vs. 2 for type II and III OPHLs), and epiglottis preservation (type "a" or type "b" resection for type II and III OPHLs). Patient's related variables were age, time from surgery, education degree and job status. Comparisons tests were used with categorical variables, while correlation analysis was performed with continuous variables.

According to the variable distribution, Kruskal–Wallis tests with Dunn's post hoc corrections for multiple comparisons or ANOVA tests with Tukey's post hoc corrections for multiple comparisons were used to detect statistical differences between more than two groups. Unpaired *t*-tests and Mann–Whitney tests were used to compare outcomes between two groups, as appropriate. Correlation analyses were carried out considering two patients-related variables (age and time from surgery) and the following outcome measures (MTP, Titze's modified spectrographic classification; SECEL Total score; "I" score of the INFVo scale; laryngoscopic variables) with the Spearman rank-order correlation coefficient or the Pearson correlation coefficient, as appropriate. An alpha of 0.05 was considered for statistical significance.

3 | RESULTS

No significant differences were found regarding mean age, education degree and job status distribution between groups of patients who underwent type I, type II, or type III OPHL; between groups of patients with different ARY/CAU status and between groups of patients with different epiglottis status.

3.1 | Surgery-related variables

Means and standard deviations for surgery-related variables, represented by the type of OPHL resection (I vs. II vs. III); the number of ARYs/CAUs preserved (1 vs. 2 considering type II and III OPHLs) and epiglottis preservation (type "a" or type "b" resection considering type II and III OPHLs) are shown in Table 2.

Concerning type of OPHL, significant differences were found between type I OPHLs and type II OPHLs for Titze's modified spectrographic classification ($p = 0.0014$); INFVO subscales "N" ($p = 0.0012$); laryngoscopic vibration parameter ($p = 0.0085$) and SECEL questionnaire subscales "T" ($p = 0.0079$) and "E" ($p = 0.0098$). Significant differences were found between type I OPHLs and type III OPHLs regarding MPT ($p = 0.0037$) Titze's modified spectrographic classification ($p = 0.0037$); INFVO subscales "I" ($p = 0.0019$), "N" ($p = 0.0337$) and "F" ($p = 0.0195$); laryngoscopic vibration parameter ($p = 0.0010$) and arytenoid motion parameter ($p = 0.0176$); SECEL questionnaire subscales "T" ($p = 0.0002$), "E" ($p = 0.0002$) and "A" ($p = 0.0006$). No significant differences were found between type II and type III OPHLs.

Concerning ARY/CAU status, significant differences were found for MPT ($p = 0.003$) with a lower mean MPT in the +ARY/CAU group. No other significant differences were found both regarding ARY/CAU status and epiglottis status.

3.2 | Patient-related variables

Means and standard deviations in the different outcome measures were compared for education and type of job as shown in Table 3. No significant differences were found for any of the investigated parameters concerning education degree. The only significant difference concerning job status was obtained for the F parameter of the INFVo perceptual scale, with a lower mean score for the employed patients ($p = 0.0188$) compared to retired or unemployed patients.

A correlation analysis was carried out considering two patient-related variables (age and time from surgery) and the following outcome variables: MPT; Titze's modified spectrographic classification; SECEL Total score; "I" score of the INFVo scale; laryngoscopic variables (vibration, arytenoid motion and closure). Significant direct correlations were found between age and the "I" score ($r = 0.36$, $p = 0.0052$) and between age and Titze's modified classification ($r = 0.29$, $p = 0.0256$), as shown in Figure 1 (the older the patient, the poorer the outcome). Significant inverse correlations were found between time

TABLE 2 Voice assessments according to the OPHL type, ARY/CAU status, and epiglottis status

	OPHL type					ARY/CAU status				Epiglottis status			
Variable	**Type I**	**Type II**	**Type III**	**Test**	***p*-value**	**Type II-III**	**Type II-III + ARY/CAU**	**Test**	***p*-value**	**Type II/IIIa**	**Type II/IIIb**	**Test**	***p*-value**
MPT (s)	11.5 ± 5.7**	9.1 ± 5.2	6.0 ± 3.2**	Kruskal–Wallis + Dunn's multiple comparisons test	0.0044*	10.43 ± 6.05	6.11 ± 2.72	Unpaired *t*-test	0.0033*	7.9 ± 4.6	5.8 ± 3.9	Mann–Whitney test	0.1349
Titze's classif.	1.5 ± 0.8**, ***	2.7 ± 1.0***	2.6 ± 1.0**	One-way ANOVA + Tukey's multiple comparisons test	0.0007*	2.8 ± 0.9	2.5 ± 1.0	Unpaired *t*-test	0.4683	2.5 ± 1.0	2.9 ± 1.2	Unpaired *t*-test	0.4506
INFVO													
I	1.9 ± 2.5**	3.6 ± 2.5	4.8 ± 2.4**	One-way ANOVA + Tukey's multiple comparisons test	0.0029*	3.5 ± 2.4	4.5 ± 2.5	Unpaired *t*-test	0.2256	4.0 ± 2.6	4.8 ± 2.3	Unpaired *t*-test	0.4626
N	0.1 ± 0.3**, ***	1.0 ± 0.9***	1.0 ± 1.5**	Kruskal–Wallis + Dunn's multiple comparison test	0.0014*	1.0 ± 1.3	1.0 ± 1.2	Mann–Whitney test	0.8988	1.1 ± 1.2	0.3 ± 0.5	Mann–Whitney test	0.0821
F	0.8 ± 1.5**	1.4 ± 1.9	3.1 ± 3.4**		0.0237*	1.6 ± 2.2	2.6 ± 3.1		0.3476	2.1 ± 2.8	3.2 ± 3.1		0.3879
Vo	0.0 ± 0.0	0.1 ± 0.6	1.1 ± 2.9		0.1757	0.2 ± 0.7	0.8 ± 2.5		0.6879	0.5 ± 2.8	1.2 ± 3.2		0.7910
Laryngoscopy													
Vibration	4.1 ± 1.6**, ***	2.5 ± 1.4***	2.2 ± 1.0**	One-way ANOVA + Tukey's multiple comparisons test	0.0007*	2.3 ± 1.2	2.3 ± 1.2	Unpaired *t*-test	0.9780	2.2 ± 1.2	2.7 ± 1.4	Unpaired *t*-test	0.2015
Arytenoid motion	4.1 ± 1.2**	3.7 ± 1.3	3.0 ± 1.2**	Kruskal–Wallis + Dunn's multiple comparisons test	0.0224*	3.7 ± 1.3	3.1 ± 1.2		0.2991	3.4 ± 1.3	3.0 ± 1.1		0.1927
Closure	4.3 ± 1.2	3.9 ± 1.0	3.6 ± 1.2		0.0626	3.8 ± 0.9	3.6 ± 1.2		0.7788	3.6 ± 1.1	4.0 ± 1.0		0.3019
SECEL													
Total	20,8 ± 12.0**, ***	34.8 ± 9.9***	40.4 ± 14.4**	One-way ANOVA + Tukey's multiple comparisons test	0.0002*	39.9 ± 15.6	36.5 ± 10.9	Unpaired *t*-test	0.4227	38.4 ± 13.0	34.0 ± 10.1	Unpaired *t*-test	0.4094
G	10.4 ± 3.0	10.9 ± 2.7	10.7 ± 1.9		0.9525	9.8 ± 2.7	11.2 ± 2.0		0.0855	10.8 ± 2.4	10.3 ± 2.1		0.5645
E	7.1 ± 7.6**, ***	16.5 ± 7.3***	19.4 ± 8.1**		0.0002*	19.7 ± 8.4	17.1 ± 7.4		0.3298	18.1 ± 8.1	17.0 ± 6.0		0.7258
A	3.2 ± 4.6**	7.5 ± 4.3	10.4 ± 7.5**	Kruskal–Wallis + Dunn's multiple comparisons test	0.0005*	10.4 ± 8.3	8.2 ± 5.0		0.3030	9.4 ± 6.6	6.7 ± 4.0		0.3143

Note: Data are reported as mean ± SD.
*, significance; **, *** significant differences at post hoc analysis.

TABLE 3 Voice assessments according to educational degree and job status

Variable (mean + SD)	Education degree: Elementary school	Education degree: High school/ bachelor	Test	*p*-value	Job status: Employed	Job status: Retired/ unemployed	Test	*p*-value
MPT (s)	10.1 ± 5.5	8.0 ± 5.2	Mann–Whitney test	0.1853	7.8 ± 4.8	9.1 ± 5.5	Mann–Whitney test	0.4523
Titze's classif.	2.5 ± 1.0	2.1 ± 1.1	Mann–Whitney test	0.2746	2.04 ± 1.1	2.3 ± 1.1	Mann–Whitney test	0.3338
INFVO								
I	3.2 ± 2.9	3.6 ± 2.7	Unpaired *t*-test	0.6686	2.6 ± 2.3	3.8 ± 2.7	Mann–Whitney test	0.1003
N	0.7 ± 1.1	0.7 ± 1.1	Mann–Whitney test	0.7028	0.6 ± 1.0	0.7 ± 1.2		0.9363
F	1.7 ± 1.8	1.8 ± 2.8		0.5813	1.1 ± 2.2	2.0 ± 2.4		0.0188*
Vo	0.2 ± 0.7	0.4 ± 2.0		>0.9999	0.5 ± 1.9	0.1 ± 0.4		0.4617
Laryngoscopy								
Vibration	2.4 ± 1.6	3.0 ± 1.5	Mann–Whitney test	0.2079	2.9 ± 1.5	2.8 ± 1.6	Mann–Whitney test	0.8740
Ary motion	3.9 ± 1.3	3.4 ± 1.3	Unpaired *t*-test	0.2277	3.3 ± 1.1	3.8 ± 1.2		0.1653
Closure	3.8 ± 1.2	3.9 ± 1.2		0.8874	4.0 ± 1.1	3.9 ± 1.2	Unpaired *t*-test	0.7312
SECEL								
Total	35.1 ± 16.6	31.5 ± 13.9	Unpaired *t*-test	0.4198	33.7 ± 16.9	30.9 ± 12.6	Mann–Whitney test	0.4827
G	10.9 ± 3.4	10.6 ± 2.2		0.7350	11.3 ± 2.8	10.3 ± 2.4	Unpaired *t*-test	0.0501
E	15.6 ± 10.3	14.3 ± 8.9		0.6483	15.1 ± 10.8	13.9 ± 7.9		0.0501
A	8.7 ± 8.1	6.6 ± 5.7		0.2890	6.7 ± 5.4	7.3 ± 7.4	Mann–Whitney test	0.7297

Note: Data are reported as mean ± SD.
*Significance.

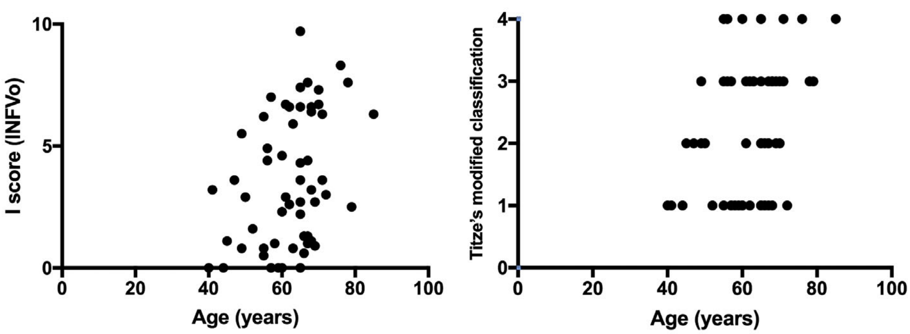

FIGURE 1 Correlations between age and the "I" score of the INFVo scale (left) and between age and Titze's modified classification (right) [Color figure can be viewed at wileyonlinelibrary.com]

from surgery and SECEL total score ($r = -0.43$, $p = 0.0006$), "I" score ($r = -0.33$, $p = 0.0103$) and Titze's modified classification ($r = -0.37$, $p = 0.0040$), meaning that longer time from surgery was associated with better mean outcome scores. Significant direct correlation was found between time from surgery and sphincteric closure

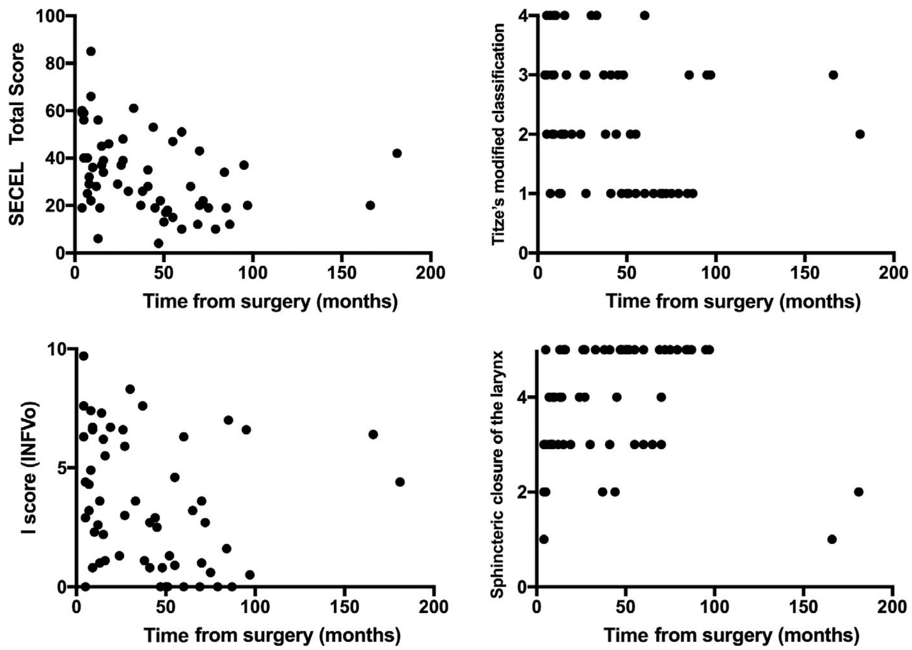

FIGURE 2 Correlations between time from surgery and SECEL total score (up left); Titze's modified classification (up right); "I" score of the INFVo scale (down left); sphincteric closure of the larynx (down right)

of the larynx ($r = 0.35$, $p = 0.0060$), meaning that longer time from surgery was associated with a better laryngeal closure, as shown in Figure 2.

4 | DISCUSSION

In the present cross-sectional outcome study, retrospective analysis on long term voice and communication outcomes after OPHLs has been carried out. Both surgery-related variables and patients-related variables were investigated. A multidimensional analysis of phonatory outcomes including acoustic, aerodynamic, perceptual and laryngoscopic evaluations and self-assessments of communication-related quality of life confirmed type I OPHL as the surgical procedure associated with better outcomes. Aerodynamic, spectrographic, perceptual, endoscopic, and self-assessment evaluations showed significantly better outcomes for type I OPHLs than type II and type III OPHL. No significant differences were found between type II and type III OPHLs. These results are not surprising since type I resections preserve the glottic plane, while type II and III OPHLs require sacrificing the vocal folds and creating a neoglottis. Consequently, phonation after type II and type III OPHLs is obtained through a substitution voice deriving from the vibration of the arytenoid mucosa with the epiglottis/base of the tongue. According to the results of our study, voice after type I OPHL is sufficiently preserved. In contrast, after type II and type III OPHL phonation is deeply affected, resulting in a hoarse and deep voice quality.

Several authors studied phonatory outcomes after open partial laryngectomy, reporting similar results to those of the present study: Topaloglu et al. investigated voice outcomes after supraglottic open partial laryngectomies, finding satisfactory perceptual and self-assessment results, albeit with worse acoustic quality and aerodynamic parameters than a healthy control group.[11] Peretti et al. reported similar phonatory outcomes after open and endoscopic supraglottic laryngectomies.[12] Other authors studied voice outcomes after supracricoid and supratracheal open partial laryngectomies, suggesting that voice is highly deteriorated, with similar results for type II and type III OPHLs.[9,10,20–22] Crosetti et al. investigated telephonic voice intelligibility after several laryngeal cancer treatments (both surgical and nonsurgical), confirming that while type I OPHL have better results, similar to those of transoral laser microsurgery, type II and type III OPHL show poorer outcomes in terms of voice intelligibility, similar to those of total laryngectomies.[23]

Concerning ARY/CAU status in type II and type III OPHLs, no significant differences in phonatory outcomes were observed except MTP, which was significantly higher in the case of both ARY/CAU preservation. The MTP is a highly investigated aerodynamic parameter after open partial laryngectomies. Several authors report reduced MPTs after partial laryngectomies, with mean durations ranging from 8 to 11 s,[9,10,18,21,24,26] but few data are available regarding the influence of ARY/CAU preservation on MPT. The present study results may be due to a better neoglottic closure during phonation because of both ARYs/CAUs movement, resulting in a stronger valving activity and longer phonation time. Despite that, the videolaryngostroboscopic evaluations did not reveal a visibly better neoglottic closure according to the ARY/CAU status. Yuce et al. investigated the effect of arytenoid resection on functional results after supracricoid laryngectomy, finding that mean decannulation, nasogastric tube removal, and hospitalization times were significantly longer in patients with one ARY resected. Albeit better phonatory outcomes (MPT, Jitt%, Shimm%, N/H) were found in the group of patients with two ARY preserved, no significant difference was detected.

Regarding the epiglottis status in type II and type III OPHLs, no significant differences were found, suggesting that the complete resection of the epiglottis (type IIb/IIIb OPHLs) may have little impact on phonation. These data are supported by other authors that found similar phonatory outcomes in type IIa and type IIb OPHLs.[17,20]

Since OPHLs can have a marked social and professional impact on the patients' lives, both education degree and job status have been considered as patient-related variables.[25] No significant differences were found according to the educational degree. No significant difference was found for the job status either, except the "fluency" parameter of the INFVo perceptual scale, suggesting that employed patients may have a mean better voice fluency. This aspect might be explained with a greater voice use by patients who are active workers, resulting in a better fluency. Nonetheless, age may play a confounding role, since active workers are younger than retired patients. Considering the age variable, significant correlations were found regarding perceptual and spectrographic evaluations, indicating that older patients may have a progressive voice quality deterioration. It is well known that the voice "gets old" in the process of presbiphonia. Besides, as reported by Crosetti et al., also the operated larynx ages, with an impact on the principal laryngeal functions.[26] Time from surgery was also found to be significantly correlated with phonatory outcomes. Better self-assessment, perceptual, spectrographic and endoscopic results were correlated with longer time from surgery, suggesting that time itself may have a role in favoring an improvement of the phonatory performance and self-acceptance of the neo-voice.

The main limitations of the present study are represented by the small sample size and the retrospective nature of the study. In the future, studies on larger populations allowing for multivariate analysis may identify independent variables associated with better voice outcomes after open partial horizontal laryngectomies.

5 | CONCLUSIONS

Phonatory outcomes after OPHLs are very heterogeneous and might be influenced by several variables. This aspect should be considered by clinicians performing such surgical procedures. The present study confirms that phonation quality after OPHL strongly depends on the type of laryngeal resection. Voice is well preserved after type I OPHLs, while is similarly deeply affected and deteriorated after type II and type III OPHLs. The preservation of both ARYs/CAUs might impact MPT, while epiglottis status does not seem to influence voice outcomes. A correlation might exist between age and distance from surgery with voice after OPHLs, with a negative impact of older age and a positive impact of longer distance from surgery on final phonatory outcomes. It is crucial for clinicians and surgeons to know which variables have higher impact on voice outcomes after OPHLs, in order to give proper information to the patients and plan a patient-tailored rehabilitative program after surgery.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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