Received: 10 September 2021 | Accepted: 20 February 2022

DOI: 10.1111/coa.13924

ORIGINAL ARTICLE

WILEY

# Long-term voice outcomes and quality of life after open partial horizontal laryngectomy type II vs. total laryngectomy: A cross-sectional study

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**Funding information**
This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors

## Abstract

**Objectives:** We aim to analyse long-term voice outcomes and quality of life (QoL) in patients undergoing open partial horizontal laryngectomy type II (OPHL type II) and to compare them to those obtained by patients undergoing total laryngectomy (TL) with voice prosthesis (VP).

**Design:** Cross-sectional cohort study.

**Setting:** Patients undergoing surgery for advanced laryngeal cancer, assessed during the usual follow-up consultations at the Phoniatric Unit (February 2020-December 2020).

**Participants:** Forty-five patients were enrolled and divided into two groups: OPHL group and TL group.

**Main outcomes measures:** Acoustic analysis, maximum phonation time, $INFV_0$ scale, I-SECEL, UW-QoL-V4 and MDADI questionnaires were used to assess the long-term outcomes.

**Results:** Voices of patients undergoing OPHL Type II were worse than those of laryngectomised patients with VP. Nevertheless, scores in voice and dysphagia-related QoL were comparable and scores in the social domain of QoL were higher in OPHL group.

**Conclusions:** Open partial horizontal laryngectomy Type II allows an acceptable voice recovery and a satisfactory QoL.

KEYWORDS
advanced laryngeal cancer, outcomes, partial laryngectomy, quality of life, rehabilitation

## 1 | INTRODUCTION

In the last decades, controlling cancer and being able to preserve the organ and its functions has become increasingly important. According to the main international guidelines, the initial treatment of advanced laryngeal cancer may consist of radio-chemotherapy protocols or conservative surgery such as open partial horizontal laryngectomy (OPHL), which include supraglottic laryngectomy (SL), supracricoid laryngectomy (SCL) and supratracheal laryngectomies (STL).[1]

Overall, OPHLs showed the potential to achieve a high 5-year local disease control rate, in over 70% of cases and were widely used in the 1980s and 1990s, particularly the SCL.[2]

Supracricoid laryngectomy can be carried out as both a primary and rescue treatment in the event of persistence or recurrence of the disease after radiotherapy.[3]

This procedure allows the maintenance of the main laryngeal functions (breathing, speech and swallowing), provided that at least one functioning cricoarytenoid unit is preserved.[4] It was developed to avoid a total laryngectomy (TL), which result in a definitive tracheostomy and irreversible loss of the laryngeal voice.

In 2014, a new systematic classification, based on the craniocaudal extent of laryngeal structures resected, was proposed[5] and what was previously called SCL has been termed 'OPHL type II' with suffixes 'a' and 'b', reflecting sparing or not of the suprahyoid epiglottis.

Dysphagia, dysphonia and aspiration pneumonia have been recognised as the main sequelae related to OPHL Type II, able to affect negatively the physical and psychological conditions of patients.[6] Dysphagia, especially for liquids, is reported in most cases, but an improvement in swallowing thanks to rehabilitation has been well-demonstrated.[7] Dysphonia is often described as severe. Despite conflicting opinions in the literature, several studies[8,9] have shown that a high percentage of patients (between 60% and 70%) reports an improvement in their vocal pattern after voice therapy, albeit lower than that obtained in dysphagia.

In several northern European countries as well as in the United States, OPHL type II is not always included in the oncological protocols. Possible reasons for this choice lie in the fact that the post-operative management is complex, and the functional results are too variable.[10]

Total laryngectomy has always been considered seriously penalising from a functional and psychosocial point of view[11] but the advent of the voice prosthesis (VP) has allowed the easy acquisition of a fluent alaryngeal speech. Primarily or secondarily implanted through a tracheoesophageal puncture (TEP), VP requires periodic replacements and careful management[12] but, with a success rate between 60% and 90%,[13] makes the surgical procedure more acceptable for the patient and his family.

Therefore, both surgical options have their pros and cons and can affect different functional domains of quality of life (QoL). Current literature reports similar local control levels and survival rates between OPHL type II and TL,[14,15] but confusing data on functional outcomes after surgery.[16–19]

The purpose of this study was to describe long-term voice outcomes and QoL in patients undergoing OPHL type II and to compare them with those achieved by patients undergoing TL with VP.

**Key Points**

1. OPHL type II can be a valid alternative to TL with a high 5-year local disease control rate, in over 70%.
2. Current literature reports confusing data on functional outcomes after OPHL type II and TL.
3. At our multidimensional assessment, OPHL group showed satisfactory objective and subjective results in terms of voice, dysphagia and QoL outcomes.
4. Comparison between OPHL and TL groups showed that voice and dysphagia-related QoL were not significantly different. After TL, voice outcomes were better but scores in the social domain of general QoL were worse.
5. OPHL type II allows obtaining satisfactory functional outcomes and it is more socially accepted because it does not require a permanent tracheostoma.

## 2 | MATERIALS AND METHODS

### 2.1 | Design

Cross-sectional cohort study (STROBE reporting guidelines).

### 2.2 | Setting and participant

Forty-five male patients were enrolled, between February 2020 and December 2020, during the annual Phoniatric visit: 22 underwent an OPHL type II (OPHL Group) and 23 a TL with VP (TL group).

Inclusion criteria were age over 18 years, Italian mother tongue, ability to produce the substitution voice, ability to provide regular written informed consent. Exclusion criteria were <1 year since treatment completion, presence of recurrent disease, sensory deficits, neurological or learning disorders.

All patients who underwent OPHL type II performed swallowing rehabilitation from the 5th post-operative day, twice daily, for 15 days during hospitalisation. After hospital discharge, patients underwent swallowing rehabilitation (8 sessions to eliminate compensatory postures) and voice therapy (10–20 sessions) in the outpatient setting.

Laryngectomised patients with VP started voice therapy after nasogastric feeding tube removal (9th post-operative day for primary TL and 12th post-operative day for salvage TL) and continued it in the outpatient clinic (from 10 to 20 sessions).

Information related to diagnosis, treatment, hospitalisation and early outcomes were collected through a retrospective review of medical records.

For the OPHL group, the anamnestic data collected were type of surgery (type IIa or IIb); primary or salvage setting; first cancer

**TABLE 1** Acoustic signal typing according to van As-Brooks et al. criteria

| | |
|---|---|
| Type I | Stable and harmonics<br>• Stable signal for a full 2 s<br>• Clear harmonics up to at least 1000 Hz |
| Type II | Stable and at least one harmonic<br>• Stable signal for a full 2 s<br>• At least one stable harmonic at the $F_0$ for a full 2 s |
| Type III | Unstable or partly harmonic<br>• Unstable signal with harmonics throughout full 2 s<br>• Absence of harmonics for <1 s |
| Type IV | Barely harmonic<br>• Complete absence of harmonics<br>• Partial absence of harmonics for more than 1 s |

treatment (surgical or radio/chemotherapy); number of preserved arytenoid units; time to swallowing recovery (i.e. the ability to feed without nasogastric tube or nutritional additional); time to tracheostomy closure (i.e. closed cannula breathing followed by surgical closure); time between surgery and enrolment; episodes of aspiration pneumonia.

For TL group, the following anamnestic data were collected: time of TEP (primary/secondary technique); primary or salvage setting; time between TL and enrolment; time between VP placement and enrolment.

## 2.3 | Main outcomes measures

### 2.3.1 | Maximum phonation time (MPT)

It was obtained by asking the patient to sustain the vowel/a/for as long as possible on a single breath. The longest of three attempts was calculated as the MPT.

### 2.3.2 | Acoustic analysis

Acoustic analysis was performed by a Phoniatrician according to the following criteria:

1. Computerized Speech Lab 4300B (Kay Elemetrics);
2. Shure model SM48 microphone (Evanston, IL, USA);
3. Microphone at 45° and 20 cm from the patient's mouth;
4. Microphone saturation input fixed at six/nine of the CH1 channel;
5. Environmental noise at <30 dB SPL;
6. Acoustic signals digitised at 20 kHz and 16 bits/sample.

*Sustained/a/*

After a visual inspection of the narrow-band (600 points) spectrograms, acoustic signal typing was performed according to the van As-Brooks criteria[20] (Table 1). Fundamental frequency ($F_0$) was extracted by using a pitch-asynchronous analysis with frame length and frame advance set to 30 milliseconds. Moreover, the $F_0$ analysis range was set from 60 to 200 Hz.

*Bisyllabic word/papà/*

The number of formant peaks ($F_1$, $F_2$, $F_3$ and $F_4$), the mean frequency of $F_1$ and $F_2$ and the $F_2$ - $F_1$ difference value were evaluated on the vowel/a/of the first syllable. The analysis of formants was performed by Fast Fourier Transform average power spectrum in the apparently most stable part of the vowel segment with a wide-band filter (128 points) and a Hamming window.

### 2.3.3 | Perceptual assessment

Two speech therapists trained in substitution voices who did not treat any of the patients in the study performed a blind perceptual assessment on recorded speech samples (reading task).

The INFVo scale, specifically designed for perceptual evaluation of substitution voices,[21,22] was used. The scale includes overall impression (I), amount of unintended additive noise (N), fluency (F) and quality of voicing (Vo). For each parameter, the score can vary from 0 to 10. The higher the score, the better is the perceived voice quality.

### 2.3.4 | Patient self-assessment

*Italian self-evaluation of communication experiences after laryngeal cancer questionnaire (I-SECEL)*

Self-report instrument that measures the perceived adjustment to substitution voice through 35 items in three subscales (General, Environment, Attitude).[23,24] Patients have to rate each statement on a 4-point categorical scale. A total score from 0 to 102 and three subscores can be obtained. A score ≥60 suggests the need for specific psychological intervention for acceptance of the new voice.

*University of Washington quality of life—version 4 questionnaire (UW-QoL-v4)*

Short multifactorial questionnaire about self-perceived QoL over the past 7 days, specific for head and neck patients.[25] It includes two subscales, each one includes six domains: the 'Physical' (chewing, speech, swallowing, taste, saliva and appearance) and the 'Social-Emotional' (anxiety, mood, pain, activity, recreation and shoulder function). For each domain, responses are rated from 0 (worst) to 100 (best). Each subscale score is the average of the six domains score. The closer the score is to 100, the better the perceived QoL.

*M.D. Anderson dysphagia inventory (MDADI)*

Self-administered questionnaire to evaluate the dysphagia-related QoL.[26,27] It includes 20 items in 4 subscales: global (GS), emotional (ES), functional (FS) and physical (PS). The composite subscale (CS) is a weighted average of the subscales. The mean score of each subscale is multiplied by 20 to obtain a score between 0, extremely low functioning, and 100, high functioning.

## 2.4 | Statistical analysis

We used the MedCalc software (version 17.9.7). For all the variables analysed, the Kolmogorov–Smirnov test was used to verify a normal distribution. The continuous numerical data, expressed as mean and standard deviation, were analysed using the Student's *t*-test as a parametric test. Instead, for categorical data, the Mann–Whitney *U* test and the Fisher exact test were used. The significance level was set at $p < .05$.

# 3 | RESULTS

Anamnestic data of OPHL group are reported in Table 2.

The two groups were homogeneous for age, gender, timing of surgery and time elapsed between surgery and enrolment (Table 3).

**TABLE 2** Descriptive statistics of the main variables concerning patients, surgery and tumours

| Characteristic | 23 patients |
|---|---|
| Age (years) | |
| Mean ± SD | 64.77 ± 7.50 |
| Range | 51–80 |
| Sex-no. (%) | |
| Male | 23 (100%) |
| Female | 0 (0%) |
| Type of surgery-no. (%) | |
| OPHL type IIa | 11 (47.82%) |
| OPHL type IIb | 12 (52.17%) |
| Arytenoids preserved-no. (%) | |
| 1 | 4 (17.39%) |
| 2 | 19 (82.60%) |
| Lesion treated by OPHL Type II-no. (%) | |
| Primary | 10 (43.47%) |
| Recurrence | 13 (56.52%) |
| After surgery | 4/13 (30.76%) |
| After radiotherapy ± chemotherapy | 9/13 (69.23%) |
| Time to swallowing recovery in days | |
| Mean ± SD | 23.61 ± 29.42 |
| Range | 10–150 |
| Need for a PEG-no. (%) | |
| Yes | 1 (4.34%)[a] |
| No | 22 (95.65%) |
| Episodes of aspiration pneumonia-no (%) | 0 (%) |
| Time to tracheostomy closure in days | |
| Mean ± SD | 25 ± 12.54 |
| Range | 10–69 |
| Time between surgery and enrolment (months) | |
| Mean ± DS | 55.91 ± 45.78 |
| Range | 12–105 |

[a]The percutaneous endoscopic gastrostomy (PEG) was temporary.

Thirteen out of 22 patients who underwent TL received the VP with a primary technique and 9 with a secondary one. In the latter case, the average time elapsed between TEP and study enrolment was 44.65 ± 16.54 months.

### 3.1 | Acoustic analysis and maximum phonation time

OPHL group showed a type I and II acoustic signal in 69.56% of cases (Type I: 9/23, 39.13%; Type II: 7/23, 30.43%).

Four formant peaks (F1, F2, F3, and F4) were recognisable in 7/23 (30.43%) cases, three in 8/23 (34.78%) and two in 8/23 (34.78%).

The mean value of the $F_0$ was 93.70 ± 25.52 Hz and the mean MPT was 12.04 ± 6.48 s.

The comparison between the two groups of patients showed that in the TL group there is a significantly higher percentage of patients with acoustic signal type I and II and with 3 or 4 formant peaks. Furthermore, in the TL group, the mean value of F1 and F2 was significantly lower ($p < .05$).

No statistically significant difference between the two groups was found in the mean value of $F_0$, in the $F_2$-$F_1$ difference and in the MPT ($p > .05$) (Table 4).

$F_0$ could not be detected in 4/23 (17.39%) patients undergoing OPHL and in 1/22 (4.54%) undergoing TL.

### 3.2 | Perceptual assessment

Patients of OPHL group obtained high perceptual scores by experienced clinicians in all parameters of the INFVo scale (Table 5). Nevertheless, voices of patients undergoing TL obtained significantly higher scores in the I and Vo parameters (Table 5).

### 3.3 | Patient self-assessment

Patients who underwent OPHL had high scores in both domains of the UW-QoL-v4 questionnaire (physical subscale mean score: 87.28 ± 16.11; social subscale mean score: 85.54 ± 14.00), in the scores of I-SECEL (mean total score: 30.70 ± 12.93) and in the MDADI questionnaire (mean total score: 78.61 ± 18.08).

No statistically significant differences were found between the two groups in the mean scores of the 'Physical' subscale of the UW-QoL-v4, as well as those of the I-SECEL and the MDADI questionnaires ($p > .05$) (Table 6). Contrariwise, patients of OPHL group obtained a mean score in the 'Social' subscale of the UW-QoL-v4, significantly higher than that obtained by patients of TL group (85.54 ± 14.00 vs. 77.54 ± 12.82; $p = .049$) (Table 6).

## 4 | DISCUSSION

Over the last 20 years, the various therapeutic options for the treatment of locally advanced laryngeal cancer (partial, total and subtotal surgical or radio-chemotherapy) have been the subject of debate. What is being discussed is the concept of preserving an organ at the expense of functional impairment without the guarantee of an effective gain in overall survival.[16]

While dysphagia has been extensively studied,[28] dysphonia received little attention. The literature limits itself to describing the poor voice outcome but provides few information on rehabilitation. Furthermore, as a standardised assessment protocol does not exist it is difficult to compare voice results.

Our multidimensional voice assessment showed satisfactory objective and subjective results. The aperiodic signal does not allow a successful acoustic analysis based on pitch detection but narrow-band spectrograms and formant analysis, together with

**TABLE 3** Patients' characteristics and treatment in both groups

| | OPHL group ($n = 23$) | TL group ($n = 22$) | $p$ values |
|---|---|---|---|
| Age (years) | 64.77 ± 7.50 (range 51–80) | 64.54 ± 11.69 (range 30–81) | NS |
| Gender | 23 M, 0 F | 22 M, 0 F | NS |
| Surgery | | | |
| Primary treatment | 14/23 (60.86%) | 18/22 (81.81%) | NS |
| Salvage treatment | 9/23 (39.13%) | 4/22 (18.18%) | |
| Time between surgery and enrolment (months) | 55.91 ± 45.78 Range 12–105 | 53.95 ± 58.25 Range 12–98 | NS |

**TABLE 4** Acoustic signal typing, number of formant peaks, mean value of $F_0$, $F_1$, $F_2$, of $F_2$-$F_1$ interval and of MPT with relative $p$ values

| | OPHL group ($n = 23$) | TL group ($n = 22$) | $p$ values |
|---|---|---|---|
| Acoustic signal typing | | | |
| Type I | 9/23 (39.13%) | 17/22 (77.27%) | .03* |
| Type II | 7/23 (30.43%) | 2/22 (9.09%) | |
| Type III | 3/23 (13.04%) | 2/22 (9.09%) | |
| Type IV | 4/23 (17.39%) | 1/22 (4.54%) | |
| Number of formant peaks | | | |
| $F_1$, $F_2$, $F_3$, $F_4$ | 7/23 (30.43%) | 13/22 (59.09%) | .01* |
| $F_1$, $F_2$, $F_3$ | 8/23 (34.78%) | 9/22 (40.90%) | |
| $F_1$, $F_2$ | 8/23 (34.78%) | 0/22 (0%) | |
| $F_0$ (Hz) (M ± SD) | 93.70 ± 25.52 | 111 ± 37.43 | NS |
| $F_1$ (Hz) (M ± SD) | 935.92 ± 94.59, | 776.13 ± 103.00 | <.001* |
| $F_2$ (Hz) (M ± SD) | 1578.00 ± 221.45 | 1407.10 ± 186.00 | .007* |
| $F_2$-$F_1$ (Hz) (M ± SD) | 642.22 ± 162.28 | 630 ± 124.60 | NS |
| MPT (s) | 12.04 ± 6.48 | 11.55 ± 5.36 | NS |

Abbreviation: NS, not significant. * indicates a statistically significance ($p < .05$).

aero-dynamic and perceptual evaluations, can provide sufficient information.

Comparison between OPHL and TL group demonstrated that laryngectomised patients with VP had a better voice than those who underwent OPHL type II. Indeed, spectrographic analysis showed a better harmonic structure (acoustic signal typing type I and II) and the detection of minimum 3 formant peaks in all patients of TL group. We found significant differences between the two groups on the average values of F1 and F2 but not in the F2-F1 interval value. As it is known, it is essential to define each vowel and, therefore, to recognise the speech. In our opinion, the higher values of F1 and F2 in OPHL group may be a direct consequence of the fixation and elevation of the neolarynx resulting in a reduction in vocal tract length.

Perceptual assessment performed trough the INFVo scale demonstrated that voice parameters (I and Vo) were significantly higher in TL group. The I parameter reflects the overall voice quality (pleasant/unpleasant; good volume or not; fluent or cut; intelligible or not), while the Vo parameter indicates if voicing is voiced or unvoiced. Despite voices after TL and after OPHL are both generated by the airflow provided by pulmonary bellows, the anatomy of vibratory structure is wide different.

In OPHL, the approximation of the mobile arytenoid cartilage(s) at the base of tongue (OPHL II b) or at the epiglottis (OPHL II a) provides the vibration source for voice production.

In contrast, the pharyngo-oesophageal segment serves as the neoglottis for voice production after TL. Since the neoglottic valve is incompetent after OPHL type II, the vibratory force generated antero-posteriorly between the arytenoid body and the epiglottis (or base of tongue) may not be as effective as that of the pharyngo-oesophageal segment after TL. Therefore, it is not surprising that the perceptual parameters in which we found a significant difference between the two groups were those directly connected to the sound source, while no differences were found in speech-related parameters (N and F).

Regarding the swallowing and breathing management of patients, our data are in line with the literature (average time to swallowing recovery and tracheostomy closure both <1 month).[10] In our previous study, it was shown that swallowing recovery is significantly longer after salvage surgery and that the time increased significantly when post-irradiation salvage cases were compared to post-operative salvage cases.[28] Furthermore, patients who retained the epiglottis had a better result in swallowing, while the sacrifice of one arytenoid had no impact on this function.[28] The present study demonstrated

**TABLE 5** INFVo scale: average scores, standard deviations and *p* values

| | OPHL group (*n* = 23) | TL group (*n* = 22) | *p* values |
|---|---|---|---|
| INFVo | | | |
| Overall impression (I) | 5.17 ± 2.46 | 7.53 ± 2.02 | .001* |
| Noise (N) | 7.48 ± 2.52 | 8.09 ± 2.39 | NS |
| Fluency (F) | 9.41 ± 1.47 | 9.05 ± 1.97 | NS |
| Voicing (Vo) | 7.07 ± 2.96 | 8.84 ± 1.89 | .021* |

Abbreviation: NS, not significant. * indicates a statistically significance ($p < .05$).

**TABLE 6** UW-Qol-v4, I-SECEL and MDADI questionnaires: average scores, standard deviations and *p* values

| | OPHL group (*n* = 23) | TL group (*n* = 22) | *p* values |
|---|---|---|---|
| UW-QOL-v4 | | | |
| Physical subscale | 87.28 ± 16.11 | 82.16 ± 13.80 | NS |
| Social subscale | 85.54 ± 14.00 | 77.54 ± 12.82 | .049* |
| I-SECEL | | | |
| Total score | 30.70 ± 12.93 | 26.50 ± 11.81 | NS |
| General subscale | 6.91 ± 2.35 | 5.86 ± 2.42 | NS |
| Environment subscale | 15.52 ± 7.70 | 12.91 ± 7.43 | NS |
| Attitude subscale | 8.30 ± 4.28 | 7.64 ± 6.02 | NS |
| MDADI | | | |
| Total score | 78.61 ± 18.08 | 71.18 ± 13.83 | NS |
| Global subscale | 3.36 ± 1.43 | 3.96 ± 1.26 | NS |
| Physical subscale | 29.57 ± 8.22 | 27.59 ± 6.63 | NS |
| Functional subscale | 20.57 ± 4.90 | 17.91 ± 4.03 | NS |
| Emotional subscale | 24.22 ± 5.36 | 22.32 ± 4.82 | NS |

Abbreviation: NS, not significant. * indicates a statistically significance ($p < .05$).

that short-term swallowing results translated into good patient satisfaction levels in the long time. Indeed, scores obtained from the MDADI questionnaire showed that dysphagia had a minimal impact on patients QoL after an average time of 5 years from surgery.

Finally, voice- and dysphagia-related QoL was not significantly different in the two groups. These data confirm what was reported in a previous study,[29] in which, despite different vocal characteristics, patients undergoing total laryngectomy and OPHL reported a similar voice-related QoL. However, total laryngectomised patients, despite the better voice outcome, reported worse scores in the Social domain of general QoL. Supposedly, the presence of the tracheostoma and the consequences related to it (i.e. repeated and sudden expectorations, coughing episodes, frequent need for cleaning and aesthetic disfigurement of the head/neck district) can negatively influence social relationships.

Our findings underlined that OPHL type II allows obtaining acceptable voice recovery, satisfactory dysphagia-related QoL. Moreover, it is more socially accepted because it does not require a permanent tracheostoma. Knowing these differences in outcome can be a determining factor in the choice of treatment by the patient and the clinician (in the case of oncologically appropriate OPHL type II indication that is same local control and survival rate as TL). We obtained interesting but exploratory findings in need of further study.

## CONFLICT OF INTEREST

All Authors declare that they have no conflict of interest.

## AUTHOR CONTRIBUTION

Lucia D'Alatri and Jacopo Galli designed the work. Lucia D'Alatri, Ylenia Longobardi, Claudio Parrilla, Fabrizio Crudo, Giuseppe Oliveto, Giorgia Mari, Maria Raffaella Marchese, Giulio Cesare Passali and Carolina Ausili Cefaro acquired and analysed data. Lucia D'Alatri and Ylenia Longobardi drafted and all authors revised and approved the manuscript. Jacopo Galli and Lucia D'Alatri agree to be accountable for all aspects of the work.

## ETHICAL APPROVAL

All procedures performed in studies involving human participants were in accordance with the ethical standards of the Ethics Committee 'Università Cattolica del Sacro Cuore' and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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[Correction added on April 13, 2022, after first online publication: Peer review history is not available for this article, so the peer review history statement has been removed.]

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**How to cite this article:** D'Alatri L, Longobardi Y, Parrilla C, et al. Long-term voice outcomes and quality of life after open partial horizontal laryngectomy type II vs. total laryngectomy: A cross-sectional study. *Clin Otolaryngol*. 2022;47:464–470. doi:10.1111/coa.13924