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HEAD AND NECK

Olfactory perception rehabilitation after total laryngectomy (OPRAT): proposal of a new protocol based on training of sensory perception skills

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Abstract

Purpose We aim to propose a new protocol for olfaction rehabilitation after total laryngectomy based on training of sensory perception levels using the Nasal Airflow-Inducing Maneuver.

Methods This is a randomized clinical trial including patients undergoing total laryngectomy between March 2010 and March 2019. Patients with nasal or oral abnormalities, prior olfaction impairment, a muco-ciliary transport time higher than 30 min, positive history for feeding, and neurological disorders were excluded. Thirty-three patients were enrolled and were randomized into two groups: an Experimental group, submitted to the new protocol (olfactory perception rehabilitation after total laryngectomy-OPRAT) and a Control group that did not receive any treatment. Subjective Olfactometry, Chemosensory Complaints Score, and University of Washington Quality of Life version 4 questionnaires were used to assess the outcomes before and after treatment, and at 3-month, 6-month, and 10-month follow-up.

Results Among the 33 patients included (32 men and 1 woman; mean age, 67.94 ± 5.64 years), 17 were subjected to olfaction rehabilitation and 16 did not receive any treatment.

At baseline evaluation, there were not significant differences between the two groups. At the end of treatment, the rehabilitated group improved their olfaction capability significantly. Such improvement remained stable over time, and after 10 months, only the Experimental group had significant improvements in all outcome measures.

Conclusions The OPRAT may guarantee excellent results in the short- and long-term time with positive effects on the Quality of Life.

Keywords Total laryngectomy · Rehabilitation · Olfaction · Quality of life · Head and neck surgery · Rhinology

Introduction

Total laryngectomy (TL) results in permanent anatomical and functional changes with a wide range of phonatory, pulmonary, swallowing, and sensory impairment. The disconnection of the upper and lower airways as well as the loss of physiological characteristics of inspired air lead to deterioration in pulmonary function with apoptosis of ciliated respiratory epithelium, hyperproduction of pulmonary secretions, cough increase, recurrent episodes of pulmonary infections, haemorrhagic tracheitis, and an impairment of smell and taste [1–3].

The loss of an orthonasal airstream results in the impossibility for odor molecules to reach the olfactory epithelium, causing subjective hypo-anosmia for the patient. However, odor molecules can reach the olfactory cleft from the oral

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cavity during feeding (retronasal olfaction), keeping the olfactory epithelium trophic after surgery. Olfaction and taste are important senses in everyday life, so their deterioration may have a strong impact on patient's quality of life (QoL) [4, 5]. Several studies investigated the effect of taste and smell loss on head and neck cancer patients, and showed that 90% of patients with these alterations experienced feelings of depression. These studies concluded that these senses are important predictors of QoL and that olfaction rehabilitation is necessary in all laryngectomized patients [6–10].

Nevertheless, contrary to vocal and pulmonary symptoms, smell impairment has received little attention in the rehabilitation practice over the years. Some authors suggested the use of particular devices, to restore olfactory function [11]. In 1986, Mozell proposed the Larynx Bypass, which consisted of a plastic tube passed from the tracheostoma into the mouth via a small plastic mouthpiece [12, 13]. Goektas suggested the Scent-diffusing Ventilator that was placed over the nose and, without mouth or tracheostoma occlusion, transported the air directly into the nose, providing a passive olfactory input [14].

Although these devices were impractical and had not been included in clinical practice, they suggested that the sense of smell in laryngectomized patients depends on nasal airflow. Indeed, results of a study by Fujii demonstrated that the function of olfactory epithelium remains intact after TL [15].

With the introduction by Hilgers of the Nasal Airflow-Inducing Maneuver (NAIM), an important technique became available for laryngectomees to regain ability to smell [16].

The NAIM consists of an extended yawning movement while keeping lips securely closed and simultaneously lowering jaw, floor of the mouth, tongue, base of tongue, and soft palate. This maneuver, also called polite yawning, creates a negative pressure in the oral cavity and oropharynx to induce orthonasal airflow [17]. Besides the NAIM, it was also proposed a "refined polite yawning technique", which consists in repetitive movements only of the base of tongue. NAIM rehabilitation results were reported by Hilgers et al. [16, 18] and Risberg-Berlin et al. [19, 20]

Success rate (consisting of an increase in the percentage of patients who moved from a no-smell condition to a smell one) was 46% after one 30-min therapy session and 72% after 3-therapy session in 6 weeks, respectively. Both authors concluded that training that is more intensive was needed to increase the percentage of successfully rehabilitated patients. The aim of the present study is to propose a new rehabilitative protocol to regain olfactory function in laryngectomized patients and to verify the stability of results over the time and the impact on QoL.

Materials and methods

Patients and study design

This is a randomized-controlled trial (RCT) of patients submitted to total laryngectomy for head and neck cancer in a single institution (A. Gemelli Hospital Foundation IRCCS, Head and Neck Surgery Area, Otorhinolaryngology, Catholic University of Sacred Heart) from March 2010 to March 2019. A copy of the trial protocol is available in the Supplement. Our internal institutional review committee approved the study. All patients provided written informed consent.

At the end of voice rehabilitation, after total laryngectomy, patients were invited to participate to this randomized clinical trial. All patients had acquired an alaryngeal voice before enrollment (esophageal voice or tracheo-esophageal voice). Patients (no: 40) fitting inclusion criteria were offered enrollment. At the screening evaluation, 6 out of them refused because of inability to attend therapy sessions on weekly basis. The enrolled patients were randomized as follow: a packet containing the patient's research identification number was placed in the patient's medical record. Randomization was performed with a block size of 8. An envelope containing the patient's randomized group assignment was not opened until baseline assessment day. The patients were randomized to one of the following two groups: Experimental group (group "E") that received olfactory rehabilitation or the Control group (group "C") that did not receive any treatment.

Flow diagram of randomized clinical trial visits is showed in Fig. 1. One patient was excluded because of unexpected death after the beginning of rehabilitation. Definitive sample, therefore, included 33 laryngectomized patients (32 men and 1 woman), with a mean age of 67.94 ± 5.64 years (range 58–80 years).

At the baseline evaluation, patients underwent subjective olfactometry, Chemosensory Complaint Score questionnaire, and UWQol questionnaire. One week after, the patients of group "E" underwent the first session and were trained to perform the maneuver. The patient was rehabilitated one a week for five sessions.

At the post-treatment assessment, patients underwent subjective olfactometry. Follow-up visits were performed at 3–6–10 months after treatment repeating subjective olfactometry, Chemosensory Complaint Score questionnaire, and UWQol questionnaire.

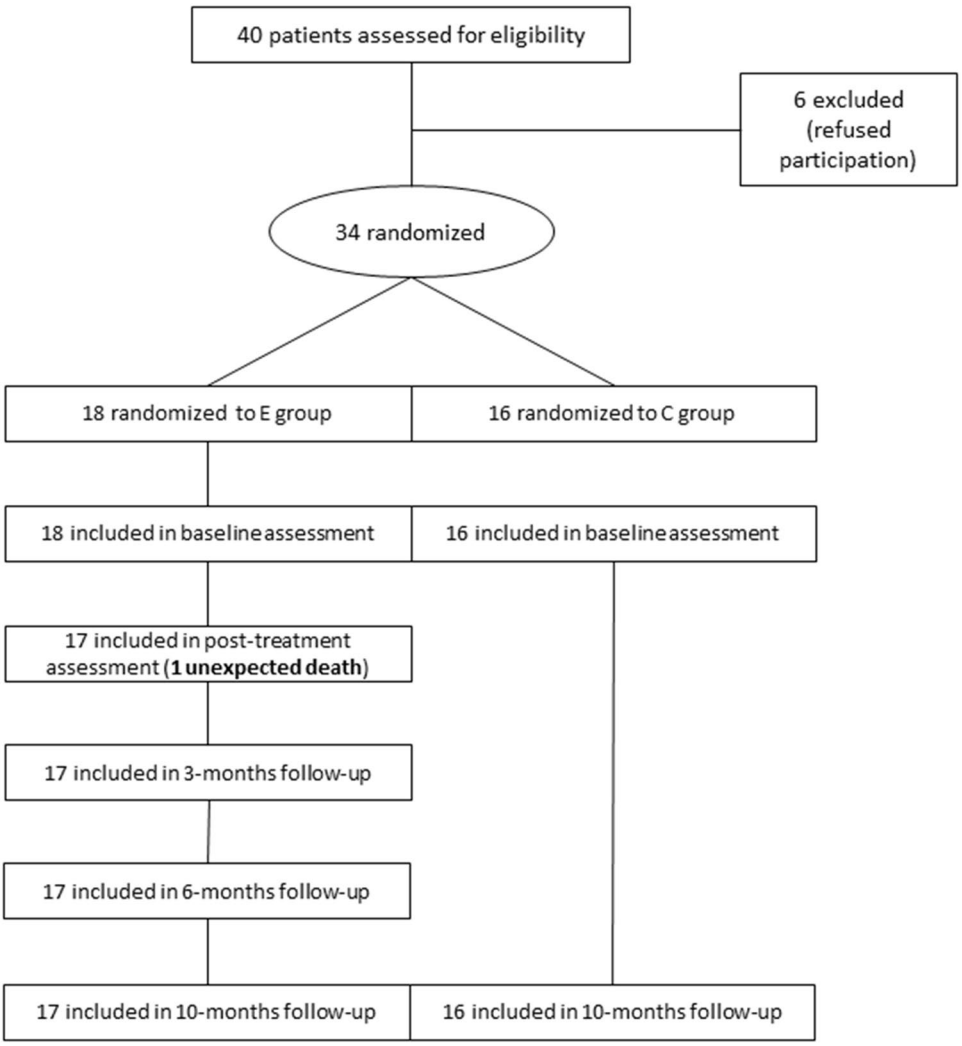

Fig. 1 Flow diagram of randomized clinical trial

Inclusion and exclusion criteria

Inclusion criteria were:

- age: 25–85;
- patients with smell impairment because submitted to total laryngectomy for head and neck cancer at least since 2 months;
- muco-ciliary transport time (Ttmc) lower than 30 min (detected using a mixture of vegetal charcoal and saccharin 3% according Passali 2000);
- patients performing speech therapy after total laryngectomy;
- patients able and willing to provide written informed consent.

Exclusion criteria were:

– radio-chemotherapy in the last 6 months;
– anatomical abnormalities detected during nasal endoscopy such as septal deviation, inferior turbinates' hypertrophy, and obliteration of the olfactory cleft);
– positive history for prior sino-nasal pathology and/or olfaction impairment such as chronic rhinosinusitis with nasal polyps or sino-nasal tumours.
– positive history for feeding issue (presence of weight loss or a composite score lower than 80 at the Italian version of the MD Anderson Dysphagia Inventory) [21];
– motility deficits of lip closure, tongue, mouth floor, and mandible,
– neurological disorders.

Olfactory perception rehabilitation after total laryngectomy (OPRAT)

Compared to the original olfaction rehabilitation proposal, we have increased the number of sessions and their frequency. In addition, a greater number of odors were used

during the exercises. Finally, training does not only include detection exercises, as previously proposed, but it follows all levels of sensory perception (detection, discrimination, identification, and recognition). OPRAT includes five 45-min training sessions performed during a 5-week period. Patients are stimulated using Sniffin' sticks, among them 10 are variable odors and 6 are fixed odors (rose and leather stimulating the olfactory nerve; cloves and mint stimulating both the olfactory and the trigeminus nerve; liquorice and anise stimulating both nerves but specially the trigeminal C fibers that lightly stings the nose). Patients are trained as in Table 1.

Training starts with detection exercises using 6 fixed odors: patients were asked to determine if they detected the presence or absence of the odor. In discrimination exercises, patient is asked to determine if two odors are equal or different. Training on identification is carried out by two activities: in the first one, the patient must smell an odor and identify it among four verbal options; in the second activity, the patient must smell four odors and find among them the one verbally requested by the speech therapist. Two types of activities are proposed also for recognition training: in the first one, the speech therapist gives an odor to the patients and asks him to recognize it by using a semantic clue; in the other one, no clues are given.

The 6 fixed odors were used in every session and in all the exercises; the 10 variable odors were gradually added during the training to gradually increase difficulty of sensory perception exercises. Therefore, at the end of therapy, the smells proposed were more and more similar to each other.

Outcome measures

- *Subjective Olfactometry* Basing on the Identification Test performance, laryngectomized patients may be categorized as smellers (score between 9 and 16) or non-smellers (score between 0 and 8) [2]. Besides that, the test allows to classify smellers as hyposmic (score between 9 and 10) or normosmic (score between 11 and 16) and non-smellers as anosmic (score between 0 and 5) or hyposmic (score between 6 and 8) [22]. The odors used to perform subjective olfactometry were different than those used during the rehabilitative training. Patients from group "E" were submitted to subjective olfactometry before, immediately after treatment and 3, 6, and 10 months later; patients from group "C" underwent to the exam at enrolling time and after 10 months. Olfactory testing was performed using an olfactory test battery developed by Kobal and Hummel in Germany in 1995, commercially available as Sniffin' Sticks. The test package comprises 112 felt-tip pens (sticks). Using Sniffin' Sticks, it is possible to assess detection, discrimination and identification threshold; the obtained results were compared to the normality scores proposed by Hummel

Table 1 Session-by-session activities of OPRAT

Session	Activities
1th	Explanation of anatomical and functional changes
	Teaching of the polite yawning maneuver
	Detection exercises with the 6 fixed odors
	Assign home exercises to the patient
2nd	Check of the correct execution of the polite yawning maneuver
	Detection exercises with the 6 fixed odors
	Discrimination and identification exercises between odors very different to each other (i.e. rose vs. leather)
	Collect the patient's weekly experiences related to the olfactory recovery
	Assign home exercises to the patient
3rd	Discrimination and identification exercises between odors different to each other (i.e. rose vs. banana)
	Recognition exercises with semantic clue by using the 6 fixed odors
	Collect the patient's weekly experiences related to the olfactory recovery
	Assign home exercises to the patient
4th	Discrimination and identification exercises between odors similar to each other (i.e. cloves vs. tobacco)
	Recognition exercises without semantic clue by using the 6 fixed odors
	Collect the patient's weekly experiences related to the olfactory recovery
	Assign home exercises to the patient
5th	Teaching of the refined polite yawning maneuver
	Discrimination and identification exercises between odors very similar to each other (i.e. liquorice vs. anise)
	Recognition exercises with and without semantic clue by using the 10 variable odors
	Collect the patient's weekly experiences related to the olfactory recovery
	Assign home exercises to the patient

normalized for age and sex [23]. In this study, a qualitative and a quantitative assessment were done. The number of random responses provided by the patients in each olfactometry was counted to perform the qualitative analysis; instead, the quantitative one was carried out by assessing the identification threshold. Identification ability is very closely related to everyday olfactory functioning, easy to perform and reliable in defining olfaction alterations. For the Identification Test, 16 odorants at suprathreshold intensity were offered to the patients. The test is based on the principle of forced multiple choice, with the correct substance having to be ticked from a list of four. Depending on the number of correctly identified substances, a result between 0 (no substance identified) and 16 (all substances identified) is obtained.

- *Chemosensory Complaint Score questionnaire* The Chemosensory Complaint Score (CCS) questionnaire allows to quantify the nature and the severity of self-perceived alterations in smell and taste. The tool gives a Taste Complaint score (0–10) on the basis of patient responses to eight questions addressing changes to the sense of taste. In the last item, one point is added for a rating of "mild" or "moderate" and two points for a rating of "severe" or "incapacitating". Similarly, a Smell Complaint score (0–6) is generated by adding one point for a positive response to each of the four questions addressing changes to the sense of smell. As for the Taste Complaint score, one point is assigned to a severity rating of "mild" or "moderate" and two points for a rating of "severe" or "incapacitating" impairment. The total score of CCS is the sum of the Taste and Smell Complaint Score; it may vary from 0 to 16: the higher score, the greater is the severity of complaint [24].
- *University of Washington Quality of Life—version 4 questionnaire* The University of Washington Quality of Life version 4 (UW-QoL-v4) questionnaire is one of the most commonly health-related QoL questionnaires used in head and neck oncology [25]. It consists of brief, multifactorial questions specific to head and neck functions and the patient's perception of QoL in the last 7 days. It is possible to obtain two subscales scores: the "Physical function" and the "Social-Emotional function" [26]. The Physical subscale score is computed as the simple average of 6 domain scores—those of chewing, speech, swallowing, taste, saliva, and appearance. The Social–Emotional subscale score is also computed as the simple average of 6 domain scores—those of anxiety, mood, pain, activity, recreation, and shoulder function. For each domain, patient's responses are rated from 0 (worst) to 100 (best). A higher mean score obtained in each subscale indicates a good outcome in terms of QoL. In this study, patients of group "E" filled out the CCS and the UW-QoL-v4 questionnaires before treatment and 3, 6, and 10 months after the end of it. Instead, patients of group "C" were asked to fill out the two questionnaires at the time of the enrollment in the study and 10 months later.

Statistical analysis

A two-sided Student's *T* test was used to analyze the difference between identification threshold (subjective olfactometry), sensory complaints (CCS questionnaire) and health-related QoL (UWQoL-v4 questionnaire) before treatment and at the end of the study in the two groups.

Changes over time of these continuous variables in the group "E" was analyzed by means of one-way repeated-measures ANOVA with Bonferroni correction, accepting p values < 0.05 as significant. Changes over time of the categorical variable (number of random responses) were analyzed by means of a McNemar test.

Clinical features of patients (subject age, smoking habit, RT-CT, time from the surgery, type of surgery, general medical conditions, and kind of voice rehabilitation) and olfactometry results were correlated by means of logistic regression.

For all statistical analysis, we used MedCalc Software (Version 17.9.7), with significance level set at $p < 0.05$.

Results

In our series, 33 patients were enrolled: 7 (21.2%) were submitted to primary TL and neck dissection (ND) without adjuvant treatment, 13 (39.4%) underwent TL + ND + radio (RT), 4 (12.1%) TL + ND + radio-chemotherapy (ChRT), and 9 (27.3%) underwent salvage TL + ND for local recurrence after radiotherapy. Average time from surgery was 40.22 ± 21.75 months (range 9–84 months).

Most of patients (30/33; 90.9%) were Tracheo-Esophageal (TE) speakers. They received an indwelling low-resistance prosthesis (Provox Vega) (Atos Medical AB, Horby, Sweden) by a primary TE puncture in 14 cases and by a secondary one in the others 16. The remaining 9.1% (3/33) were Esophageal (E) speakers.

Seventeen patients were randomized to the group "E" and sixteen patients were randomized to the Control group. Data of the two groups are summarized in Table 2. For all continuous variables analyzed (Identification threshold, CCS, and UWQoL-v4 average scores), the Kolmogorov–Smirnoff test showed a normal distribution.

Subjective olfactometry

At the baseline the mean Smell Identification threshold of group "E" and "C" was quite similar (6.05 ± 0.71 vs.

Table 2 Patients' characteristics

	Experimental group ($N=17$)	Control group ($N=16$)
Sex	16 M; 1 W	16 M
Mean age (years)	66.57 ± 4.43	68.43 ± 5.32
Primary TL + adjuvant RT-CT treatment	1/17	3/16
Primary TL + adjuvant RT treatment	8/17	5/16
Primary TL without adjuvant treatment	3/17	4/16
Salvage TL	5/17	4/16
TE voice	15/17	15/16
E voice	2/17	1/16
Average time from surgery to olfaction rehabilitation (months)	41.34 ± 23.21	39.21 ± 25.76
Smoking patients	13/17	14/16

M man, *W* woman, *RT-CT* radio-chemotherapy treatment, *TE* trachea-esophageal, *E* esophageal, *TEP* trachea-esophageal puncture, *TL* total laryngectomy

6.15 ± 0.86; $p > 0.05$). At 10 month follow-up, evaluation group "E" had significantly higher mean Identification threshold than the group "C" (13.58 ± 0.45 vs. 7.25 ± 0.07; $p = 0.0005$) (Fig. 2a).

Pre-treatment Subjective Olfactometry showed that 11/17 (64.7%) patients of group "E" were no smellers (8 of them were anosmic and 3 were hyposmic) and that 6/17 (36.3%) were smellers (all hyposmic). Immediately after the end of treatment, all patients resulted smellers [only one of them was hyposmic, 16/17 (94.11%) were normosmic]. Mean number of random responses immediately after the end of treatment was significantly lower than pre-treatment (0.11 ± 0.33 vs. 5.05 ± 4.81; $p < 0.0002$). At 3, 6, and 10 month follow-up assessment, no patient provided any random response and all subjects remained smellers, in particular 14 normosmic, 3 hyposmic (success rate = 100%).

In the group "E" immediately after the end of treatment, the average score of Identification threshold was significantly better than pre-treatment (13.00 ± 0.58 vs. 6.05 ± 0.71; $p < 0.0001$). Identification threshold average scores obtained 3, 6, and 10 months after the end of treatment were significantly higher than the ones at the baseline (12.52 ± 0.63, 12.52 ± 0.59 and 13.58 ± 0.45 vs. 6.05 ± 0.71, respectively; $p < 0.0001$). However, comparison between each follow-up evaluation and between these and the evaluation performed immediately after the end of treatment did not show any significant difference ($p > 0.05$) (Fig. 2b).

At the enrolling evaluation, 13/16 (81.25%) patients of group "C" were no smellers (9 were anosmic and 4 were hyposmic); 3/16 (18.75%) were smellers (all hyposmic). No significant changes were detected 10 months after the first evaluation (6.15 ± 0.86 vs 7.25 ± 0.07; $p > 0.05$).

No correlation was found between olfactometry results and: patient's age, smoking habit, type and time from surgery, general medical conditions, and type of voice rehabilitation.

Chemosensory complaint score questionnaire

At the baseline, the difference about Smell Complaint mean scores between group "E" and "C" was not statistically significant (3.88 ± 0.17 vs. 4.15 ± 0.36; $p > 0.05$). In the group "E" at 10 month follow-up evaluation, we observe a significantly lower smell complaint mean scores than group "C" (2.41 ± 0.28 vs. 4.25 ± 0.37; $p = 0.0004$) as showed in Fig. 3a.

At baseline assessment, a statistically significant difference about Taste Complaint mean scores was found between group "E" and "C" (3.05 ± 2.86 vs. 7.06 ± 2.17; $p = 0.003$). Therefore, it was not possible to perform any comparison between the two groups 10 months later.

The mean score of Smell Complaint subscale in group "E" progressively improved 3, 6, and 10 months after the end of treatment. However, only the differences between pre-treatment and follow-up evaluations both at 6 and 10 months were statistically significant and respectively 3.88 ± 0.18 vs. 2.88 ± 0.28 ($p = 0.002$) and 3.88 ± 0.18 vs. 2.41 ± 0.28 ($p = 0.0001$) as showed in Fig. 3b.

Also the mean score of Taste Complaint subscale in group "E" progressively improved over time and at 10 month follow-up evaluation became significantly lower than pre-treatment (2.23 ± 0.48 vs. 4.17 ± 0.72; $p = 0.002$).

The average Total Complaint scores obtained 3, 6, and 10 months after the end of treatment were significantly lower than that obtained at pre-treatment assessment (5.70 ± 0.58, 5.88 ± 0.61, and 4.64 ± 0.59 vs. 8.05 ± 0.80, respectively; $p = 0.01$).

Finally, comparison between each follow-up evaluation did not show any significant difference ($p > 0.05$).

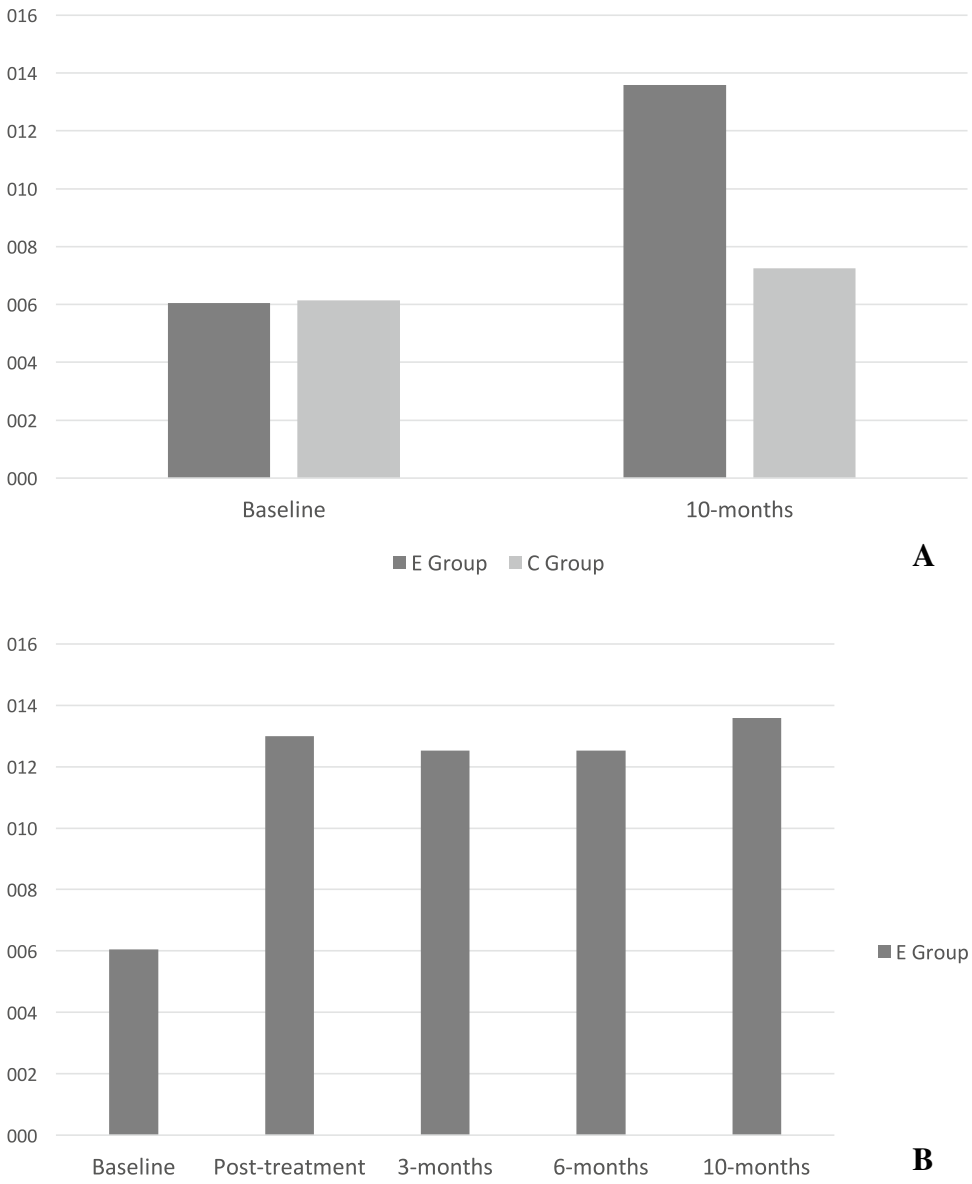

Fig. 2 Smell identification threshold: average score of group "E" and group "C" at baseline evaluation and at 10 month follow-up evaluation (**a**); average score obtained by group "E" at each evaluation (**b**)

University of Washington Quality of Life—version 4 questionnaire

Statistical analysis did not show any significant difference between group "E" and "C" about baseline UW-QoL-v4 Physical (74.11 ± 2.26 vs. 75.75 ± 3.33; $p > 0.05$) and Social–Emotional subscale average scores (74.48 ± 2.51 vs. 75.51 ± 3.06; $p > 0.05$). At 10 months follow-up evaluation group, "E" had significantly higher average scores than group "C" only in the Physical subscale (84.06 ± 2.85 vs. 77.75 ± 4.03; $p = 0.046$) as showed in Fig. 4a.

Compared to pre-treatment assessment, the UW-QoL-v4 physical subscale average score in group "E" progressively improved 3, 6, and 10 months after the end of treatment. However, only the differences between pre-treatment and follow-up evaluations both at 6 and 10 months were statistically significant and, respectively, 74.11 ± 2.26 vs. 82.52 ± 2.64 ($p < 0.004$) and 74.11 ± 2.26 vs. 84.06 ± 2.85 ($p < 0.005$) as showed in Fig. 4b.

Finally, for the Social–Emotional subscale, no statistically significant differences of average scores were found over time ($p > 0.05$).

Discussion

The aim of this paper was to propose, for the first time, a new olfaction rehabilitation protocol—the OPRAT—based on the use of NAIM and on a training of sensory perception levels. For all levels of sensory perception, the OPRAT has been designed to become increasingly difficult. Indeed, while at the beginning of the training, very dissimilar odors

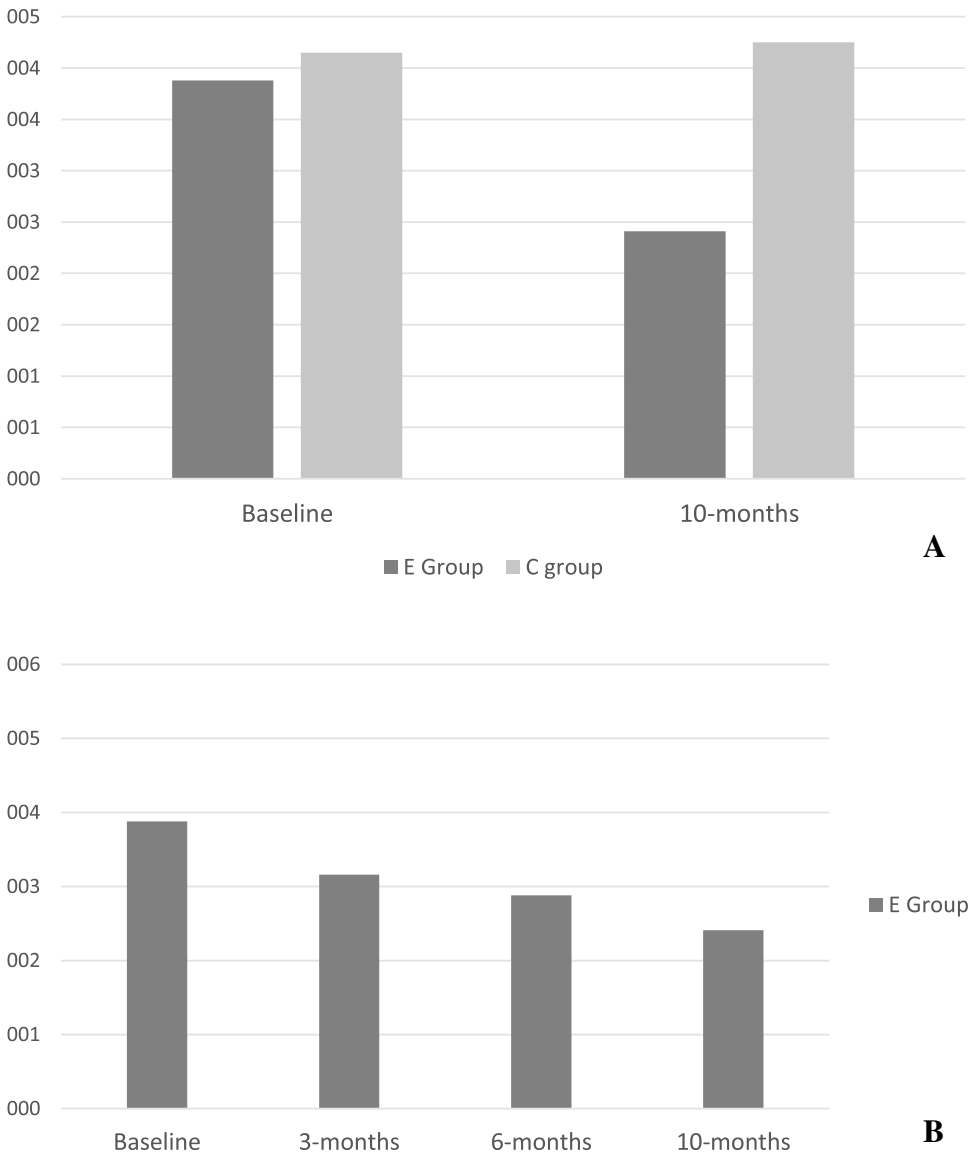

Fig. 3 Smell Complaint Chemosensory questionnaire: mean scores of group "E" and group "C" at baseline evaluation and at 10 month follow-up evaluation (**a**); mean scores obtained by group "E" at each evaluation (**b**)

were used, at the end of it, the smells proposed are more and more similar to each other.

Our results show that at post-treatment assessment and at each follow-up evaluation, all patients were in the smeller category (success rate of 100%). Moreover, identification threshold average scores obtained at each follow-up assessment were significantly higher than that obtained at pre-treatment assessment and did not lower over time.

Hilgers introduced the olfaction rehabilitation with NAIM in 2000 [16] proposing only one 30-min therapy session and obtaining a success rate of 46%. In a later study [18], he showed that only 50% of patients were able to maintain the results of olfaction rehabilitation in the long term, demonstrating that for many patients, a single therapy session may be not sufficient to restore and to maintain olfactory sensitivity. The need for more sessions was also claimed by Risberg–Berlin who showed that 72% of patients became smellers by performing three therapy sessions within 6 weeks [19]. One year after, 88% of these patients were still in the smeller category [20].

Our better results may be explained by the higher number of sessions and the peculiar characteristic of the OPRAT. By performing five-therapy sessions, we ensure that patients appropriately learn the NAIM and encourage them to make regular use of it in everyday life. Furthermore, the hierarchical stimulation of each level of sensorial perception could gradually encourage the recall of the olfactory traces present in the memory.

The absence of any correlation between the obtained results and the patients' features (mostly patient's age, smoking habits and time from surgery) suggests that the OPRAT may be widely diffused and easily generalizable.

After TL, voice and pulmonary symptoms are commonly considered more invaliding than the loss of smell. Therefore,

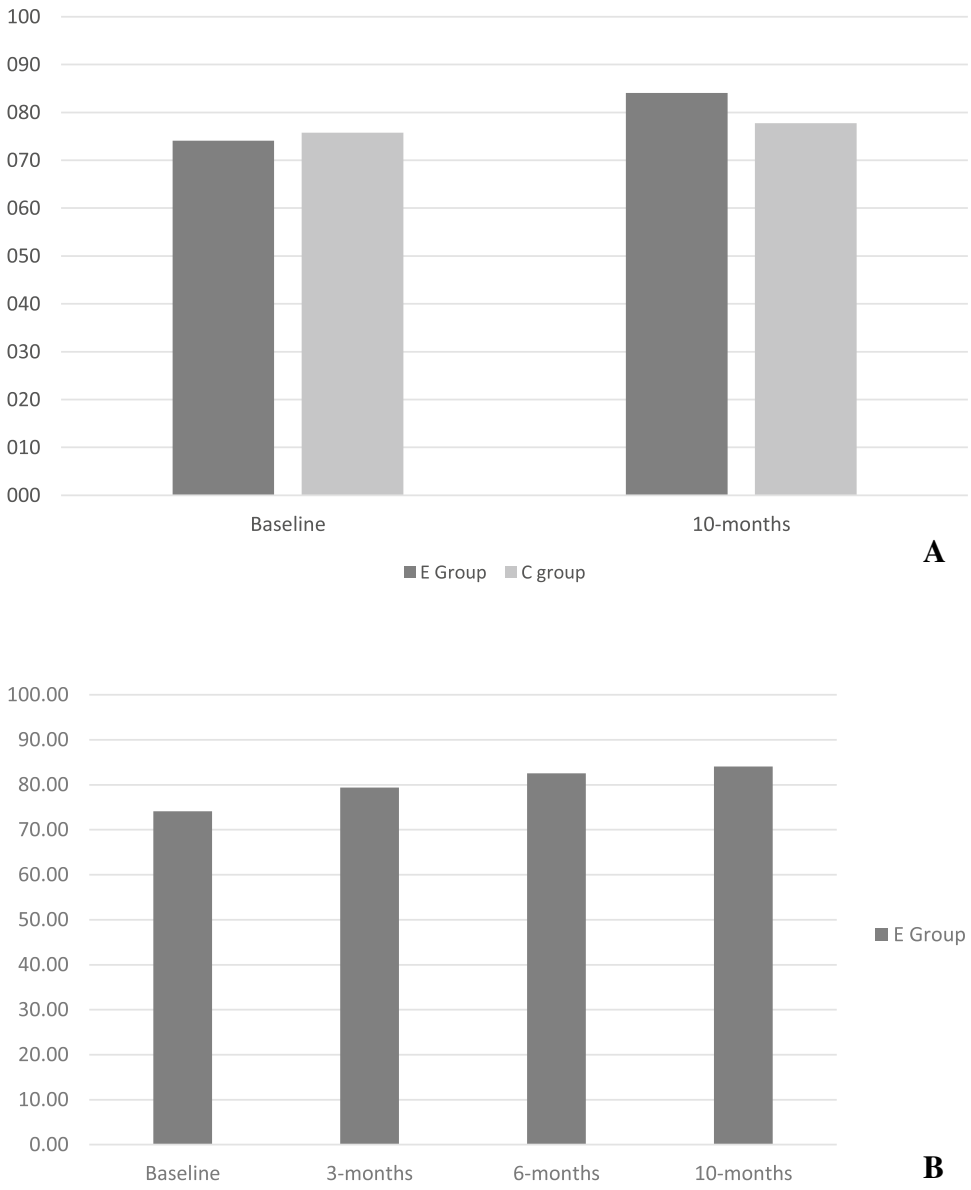

Fig. 4 Physical subscale of UWQoL questionnaire: mean scores of group "E" and group "C" at baseline evaluation and at 10 month follow-up evaluation (**a**); mean scores obtained by group "E" at each evaluation **(b)**

olfactory rehabilitation often receives little attention in the clinical practice. Nowadays, there are a few contributions in the literature about the effect that olfaction rehabilitation may have on patient's QoL [27, 28].

In this study, self-perceived smell and taste functions were assessed by the CCS questionnaire that quantifies the nature and the severity of sensorial alterations. The results showed that only patients who underwent OPRAT had a reduction in the degree of self-perceived olfactory sensory handicap that progressively improved over time.

Taste and smell alterations are one of the most common complaints in laryngectomized patients. Loss of taste and smell can cause more than just a reduced dietary intake and weight loss. Indeed, as smell and taste trigger memories and emotions, it may be very hard to deal with their loss in daily life.

At the time of enrollment in the study, patients of group "E" and "C" did not show any significant difference in the UW-Qol-v4 questionnaire average scores. At 10 month follow-up evaluation, only the group "E" had significantly higher average scores in the physical subscale. This result allows us to affirm that the improvement was due to olfaction rehabilitation alone and no to other factors.

The significant improvement obtained only in the physical subscale may be explained by the peculiar composition of the two subscales. Indeed, on the Social–Emotional domains—anxiety, mood, pain, activity, recreation, and shoulder function—olfaction rehabilitation cannot act. Most of the Physical subscale domains (chewing, swallowing, taste, and saliva), on the contrary, can be influenced by the restoration of olfactory sensitivity.

Conclusions

In our series, even if it is of a small court of subjects, we found that olfaction rehabilitation performed more times and, following the sensory perception levels, could be more effective than the way suggested by studies already published.

An important endpoint of rehabilitation after TL is to recover an adequate QoL. A severe mutilation such as that suffered by laryngectomized patients may be better tolerated with a global management that provides not only vocal and pulmonary rehabilitation but also the olfactory one.

Author contributions All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by YL, CP, GDC, MEM, GM, and EC. YL wrote the first draft of the manuscript and all authors commented on the previous versions of the manuscript. GP, LD, and GCP supervised this research. All authors read and approved the final manuscript.

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Compliance with ethical standards

Conflict of interest statement All authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the Medical Ethics Committee of the Catholic University of the Sacred Heart and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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