ORIGINAL CONTRIBUTION

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Usefulness and feasibility of psychophysical and electrophysiological olfactory testing in the rhinology clinic*

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SUMMARY

Topic: *Olfactory dysfunction may be assessed in the clinic with psychophysical testing and electrophysiological recording. Chemosensory event-related potentials (CSERPs) constitute an objective method to assess chemosensory function. Olfactory and trigeminal stimuli activate chemoreceptors from the olfactory neuroepithelium and from the nasal mucosa to evoke an electrophysiological response respectively called olfactory (OERPs) and trigeminal ERPs (TERPs). The purpose of this study is to assess the usefulness and feasibility of these diagnostic tools in the rhinology clinic and to correlate these results to the olfactory disorder aetiology.*

Materials and Methods: *This study encompasses a cohort of 229 patients with a complaint of olfactory dysfunction from different origins. Orthonasal (Sniffing stick test with the treshold-discrimination-identification score: maximal score 48) and retronasal olfactory (maximal score 20) testing as well as CSERPs both after olfactory and trigeminal stimuli have been routinely performed. Olfactory dysfunction aetiologies were as follows: congenital (Cong.), chronic rhinosinusitis (CRS), idiopathic (Idiop.), post-medication (PM), neurologic (Neuro.), post-traumatic (PT) and post-infection (PI).*

Results: *Mean orthonasal and retronasal scores were respectively: 11.8 and 10.1 for Cong., 18.5 and 13.1 for CRS, 15.6 and 10.4 for Idiop., 15.3 and 10.2 for PM, 17 and 10.6 for Neuro., 15 and 9.9 for PT and 18.3 and 12 for PI. Correlations between orthonasal and retronasal scores were present for all subgroups except congenital and chronic rhinosinusitis subgroups. Orthonasal and retronasal scores were different ($p < 0.05$) when comparing CRS vs Cong., CRS vs PT and PT vs PI. Technical problems (olfactometer or olfactory stimulation, EEG amplifier,...) and patients discomfort (anxiety, stress,…) did not allow to draw any conclusion in 2 patients. Three patients after olfactory stimulus and 6 patients after trigeminal stimulus demonstrated too much eye blinking or muscular artifacts that did not allow us to perform electrophysiological analysis and averaging as 60% of artifact-free recording was not achieved. Olfactory ERPs were recorded in 28% of the patients and trigeminal ERPs were obtained in almost every patient (95%). There was no statistical difference between each subgroup regarding the presence or absence of OERPs.*

Conclusions: *Psychophysical olfactory testing is a useful method to assess olfactory function in patients with olfactory loss and may help us to obtain a semi-objective and a basal evaluation of the olfactory performances. Feasibility and usefulness of CSERPs are also underlined in this study with only a limited number of patients who did not complete the examination. Psychophysical testing gives different results according to the aetiology of the olfactory disorder, which was not the case for electrophysiological recording. Olfactory acuity assessment should be based on psychophysical and CSERPs evaluation in a clinical setting.*

Key words: smell, olfaction, chemosensory event-related potential, olfactometer, olfactory and trigeminal informations, orthonasal testing, retronasal testing

INTRODUCTION

A number of techniques have been developed to assess olfactory function in healthy subjects and patients complaining of olfactory dysfunction. Standardized psychophysical tests which address both orthonasal or retronasal chemoreception are now readily available [1-4]. The recording and assessment of chemosensory event-related brain potentials (CSERPs) has been proposed as a reliable alternative method for the evalua-

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tion of olfactory function, both after olfactory (OERPs) or trigeminal (TERP) stimuli. As compared to psychophysical methods, electrophysiological recording does not require subject cooperation and collaboration [5-7]. Finally, structural MRI and functional MRI also allow assessment of the morphology and structure of the olfactory apparatus as well as the localization of activated brain areas in response to chemosensory stimulation [8,9].

In the following study, our routine psychophysical and electrophysiological methods of investigating chemosensory function will be outlined and their clinical usefulness will be discussed and illustrated through a selection of clinical examples. Feasibility of CSERPs in rhinology clinic and results obtained in a large population of patients with olfactory disorder will be reported. Presence or absence of event related potentials after olfactory or trigeminal stimulus will be reported. Data comparison based on psychophysical testing and CSERPs between different subgroups of patients will also be outlined. The aim of the study was to evaluate the feasibility of CSERPs in the rhinology clinic and to compare results from psychophysical and electrophysiological evaluation regarding the olfactory disorder aetiology.

MATERIAL AND METHODS

Patients

From September 2005 to December 2007, patients with olfactory disorder presenting at the Cliniques Universitaires Saint-Luc (Brussels, Belgium) outpatient clinic were prospectively included in a study of their olfactory performances.

Investigations of olfactory function have been mostly conducted in patients presenting olfactory dysfunction related to chronic rhinosinusitis (CRS) (with and without nasal polyposis), post-infection olfactory event (PI), post-traumatic olfactory event (PT), congenital olfactory dysfunction (Cong.), toxic and/or post-medication olfactory event (PM), neurological disease (Neuro.) and idiopathic olfactory dysfunction (Idiop.). This should not be considered as representative of the prevalence of the different causes possibly leading to olfactory disorder but rather as the patient's proportion seen in our outpatient clinic with olfactory dysfunction as the main symptom.

Psychophysical olfactory testing

Subjects were examined using anterior rhinoscopy and endonasal endoscopy. Olfactory performances were assessed using psychophysical testing (orthonasal and retronasal) and electrophysiological studies (chemosensory event related potentials). The study subjects were asked not to eat, drink, or smoke for at least two hours before the experimental session. The basic principle underlying the psychophysical testing of orthonasal olfactory function is to present subjects or patients a controlled olfactory stimulus and interpret their responses and reactions. Testing of odour threshold (T), odour discrimination (D), and odour identification (I) may be performed with the "Sniffin' Sticks" Test. Results from the 3 subsets of this test are frequently concatenated into the so-called "threshold-discrimination-identification (TDI) score". A series of 16 tests for the three different subsets leads to a maximal score of 48. The duration of the procedure was between 20 and 30 minutes. For healthy subjects, the TDI score at the 10th percentile is 24.9 in subjects younger than 15 y, 30.3 for ages 16–35 y, 27.3 for ages 36–55 y and 19.6 for subjects over 55 y. Hyposmia was defined as the 10th percentile score of 16–35-y-old subjects. The cut-off value for functional anosmia is 15,5 [2].

To evaluate the retronasal olfactory function, a previously standardized testing procedure was used, based on the presentation of odorized powders in the patient's mouth [4]. Twenty different odorous powders were applied to the midline of the tongue on a fenestrated plastic stick for a duration of 3 seconds. Participants were asked to identify the presented odour from a list of four items. It should be noted that great care must be taken to avoid concomitantly stimulating the patient orthonasally by simply passing the powder at the level of the nares. Subjects were asked to block the nose and not to skew the tongue, such as to avoid decreasing the surface contact with taste receptors. Following the presentation of each odorant powder, participants rinsed their mouth with clear water. In healthy subjects, the median retronasal testing score was 18 for subjects aged 36–55 years and 16 for subjects older than 55 years [4].

Chemosensory event related potentials

Clinical testing with chemosensory ERPs includes the recording of brain cortical responses to olfactory and trigeminal stimuli. Olfactory and trigeminal stimuli activate chemoreceptors from the olfactory neuroepithelium and from the nasal mucosa to evoke an electrophysiological response respectively called olfactory (OERPs) and trigeminal ERP (TERPs) or chemosomatosensory ERPs [5,7]. Most odorants stimulate both chemosensory systems but in order to selectively assess the responses elicited by trigeminal and olfactory stimulation, specific stimuli must be used. To produce a purely olfactory stimulus, many studies have relied on the use of vanillin, 2-phenyl ethyl alcohol (2-PEA), hydrogen sulfide (H_2S) or amyl acetate. To produce a purely trigeminal somatosensory stimulus, carbon dioxide (CO_2) is most frequently used [5,7].

To elicit consistent chemosensory ERPs, the stimulus presentation is critical in terms of intensity, duration, interstimulus interval, humidity, and temperature. Most importantly, the presentation of the olfactory stimulus may not be accompanied by any simultaneous mechanical stimulation (such as it would be if odours were presented in an air puff). A solution to this difficult problem was proposed by Kobal (1981), who devised an olfactometer capable of embedding odorant pulses within a constant flow of odourless air.

Chemosensory ERPs must be recorded in a quiet, but also a well-ventilated room. Eye movements and eye blinks should

be minimized by asking subjects to refrain from blinking, or, by asking subjects to perform a simple eye-tracking task on a video monitor in front of them. The sounds associated with stimulus presentation should be masked, for example using a 60 – 70 dB binaural white noise presented through headphones. The outlet of the stimulator is placed in one nostril, just beyond the nasal valve (approximately 10 mm from the nares). Airflow presented during the inter-stimulus interval must be odour-free, warmed to body temperature, and have more than 80% relative humidity.

The bulk of chemosensory ERPs lies within a 2 – 8 Hz frequency range. Therefore, in the majority of experimental and clinical studies, the recorded EEG may be band-pass filtered (e.g. 0.3 – 20 Hz). For clinical studies, scalp recording sites usually include three midline electrodes (international 10/20 positions FZ, CZ, and PZ) referenced to linked earlobes (A1A2). In most circumstances, the recording of reliable chemosensory ERPs requires the recording and averaging of 10 – 30 consecutive trials.

CSERPs were considered as present if the averaged waveforms demonstrated a negative-positive complex consisting of an initial negative peak (N1: latency: 290 – 490 ms, amplitude $< -2\ \mu V$) followed by a positive peak (P2: latency: 460 – 820 ms, amplitudes $> +2\ \mu V$). Responses were independently analysed by two different observers (PR and AM). A minimum of 60% of artefact free recording was considered as the limit allowing any further interpretation of the CSERPs (12/20 trials).

Routine procedure included 20 stimuli of pure olfactory stimulus (PEA) and 20 stimuli of trigeminal stimulus (CO_2). The interstimulus interval was 30 seconds and stimuli were applied in a consecutive way. The duration of the procedure was between 30 and 45 minutes.

Statistics

Comparison between subgroups for orthonasal and retronasal scores were studied using LSD test. A p-value below 0.05 was considered as statistically significant. Correlations between orthonasal and retronasal scores were evaluated using Pearson's correlation. Presence or absence of OERPs and TERPs were studied in the different groups. Pearson's Chi-squared test was used between a subgroup and the presence or absence of OERPs and between anosmic/hyposmic vs presence or absence of OERPs.

RESULTS

Psychophysical olfactory testing (orthonasal and retronasal) and CSERPs were recorded in 229 patients. Aetiologies of the olfactory disorder revealed; 8 congenital (3.5%), 47 chronic rhinosinusitis (20.5%), 24 idiopathic (10.5%), 10 post-medication (4.4%), 16 neurologic (7%), 63 post-traumatic (27.5%) and 61 post-infection (26.6%) (Table 1). Mean age was 51 years old with 10 patients between 15-24, 19 between 25-34, 42 between 35-44, 62 between 45-54, 51 between 55-64, 37 between 65-74 and 8 above 75 years old. There were 122 women (53.3%) and 107 men (46.7%).

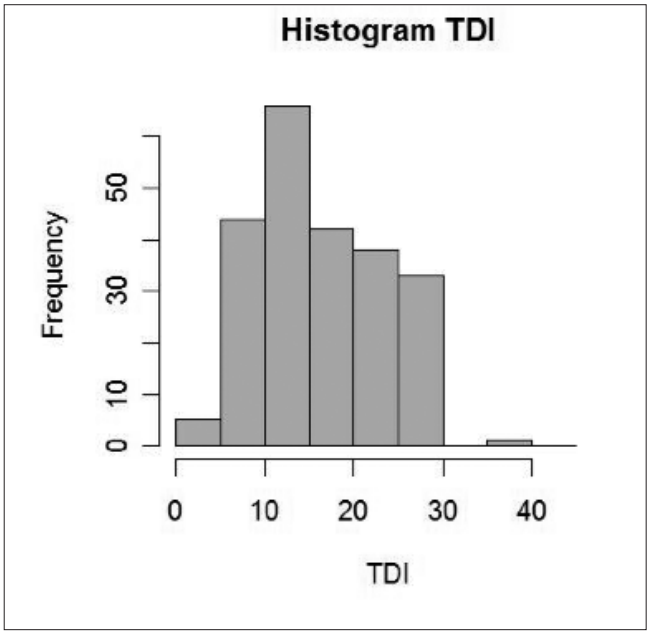

Figure 1. Histogram orthonasal scores (TDI).

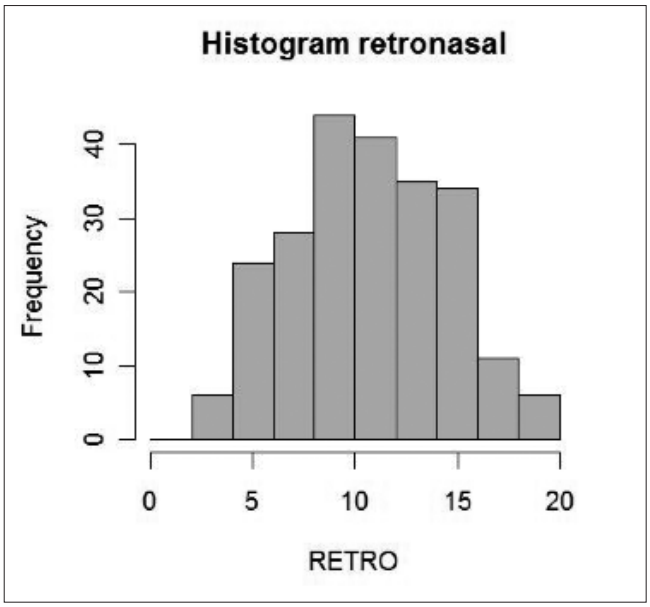

Figure 2. Histogram retronasal scores.

Orthonasal scores revealed a mean value of 16 (SD ± 6.9) with all the patients demonstrating a value below 30 except for one (Figure 1). According to the arbitrary cut-off between hyposmic and anosmic patients, 114 were considered as hyposmics and 115 as anosmics. Retronasal mean score was 11 (SD ± 3.8) with the majority of the patients between 5 and 15 (Figure 2). Mean TDI scores, standard deviation and 95% confidence interval for each subgroup were as follows: Cong.: 11.8, 1.9 and 7.0-16.5, CRS: 18.5, 7.2 and 16.5-20.4, Idiop.: 15.6, 6.6 and 12.9-18.3, PM: 15.3, 7.1 and 11.1-19.5, Neuro.: 17, 8.1 and 13.7-20.3, PT: 15, 6.8 and 13.4-16.7, and PI: 18.3, 6.4 and 16.6-20.

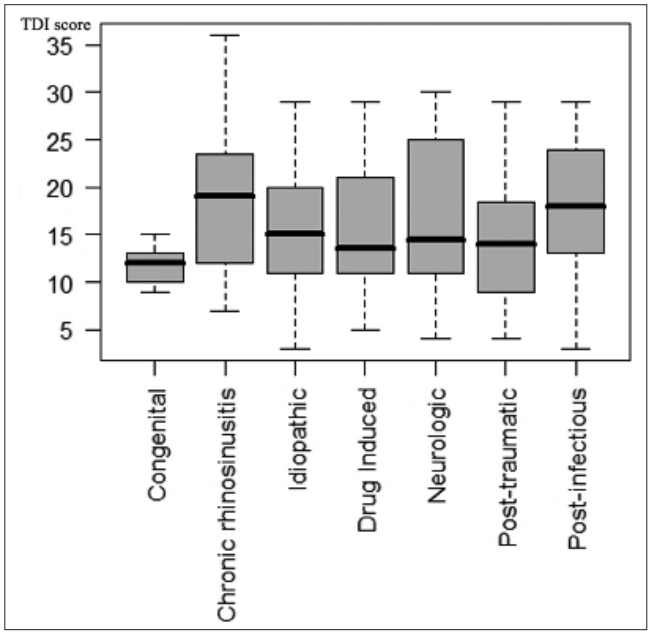

Figure 3. Orthonasal scores vs different aetiologies of olfactory dysfunction.

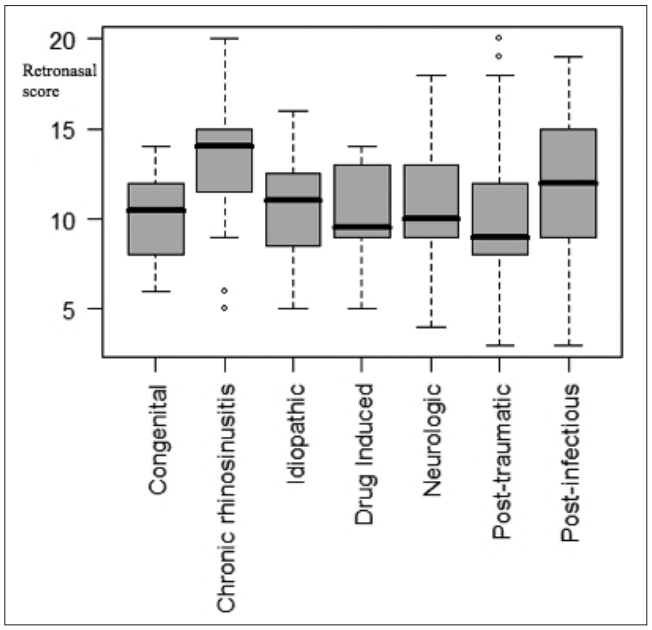

Figure 4. Retronasal scores vs different aetiologies of olfactory dysfunction.

Figure 3 represent orthonasal scores related to the aetiology of the olfactory disorder. LSD comparison test between mean TDI scores from 2 subgroups of patients revealed a statistically difference between congenital and chronic rhinosinusitis ($p = 0.012$), between congenital and post-infectious ($p = 0.006$, between chronic rhinosinusitis and post-traumatic ($p = 0.012$) and between post-infectious and post-traumatic ($p = 0.006$). Regarding the retronasal scores, mean scores, standard deviation and 95% confidence interval related to the different aetiologies were as follow; Cong.: 10.1, 2.7 and 7.6-12.6, CRS: 13.1, 3.4 and 12.1-14.2, Idiop.: 10.4, 3.1 and 9.0-11.9, PM: 10.2, 2.9 and 7.9-12.5, Neuro.: 10.6, 3.5 and 8.8-12.4, PT :9.9, 3.9 and 9.0-10.8 and PI: 12, 3.8 and 11-12.9.

Figure 4 represents the retronasal scores according to the aetiology of the olfactory disorder. LSD comparison test between mean retronasal scores from two subgroups of patients revealed a statistical significant difference between chronic rhinosinusitis and congenital ($p = 0.022$), idiopathic ($p = 0.002$), neurologic ($p = 0.014$), post-traumatic ($p < 0.001$), and between post-infectious and post-traumatic ($p = 0.003$).

Table 2 represents the statistical significant differences between subgroups for total TDI, threshold, discrimination, identification and retronasal scores.

Correlations between TDI scores and retronasal scores demonstrated for the entire cohort of 229 patients a significant correlation: Pearson correlation coefficient = 0.551 and $p < 0.0001$. In the subgroups, CRS (Pearson correlation coefficient = 0.149 and $p = 0.317$) and Cong. patients (Pearson correlation coefficient = -0.180 and $p = 0.669$) had no correlation between their orthonasal and their retronasal scores. On the contrary, the other subgroups had a significant correlation: Idiop.: P. coeff. = 0.530 and $p = 0.008$, PM: P. coeff. = 0.756 and $p = 0.01$, Neuro.: P. coeff. = 0.660 and $p = 0.005$, PT: P. coeff. = 0.592 and $p < 0.001$, PI: P. coeff. = 0.701 and $p < 0.001$ (Figure 5).

CSERPs recordings were performed and started for all the patients. Two patients did not undergo the entire experiment due to technical problems and no data could be obtained for them. Studies were incomplete for 3 patients after olfactory stimulus and for 6 patients after trigeminal stimulus, in the context of recording not yielding > 60% of artifact free stimuli, resulting on not being possible to extract event related potentials after averaging. OERPs were recorded in 64/229 (28%) patients and TERPs in 219/229 (95%) patients. Presence of OERPs is reported according to the different aetiologies; Cong. for 12% of the patients, CRS: 30%, Idiop.: 8%, PM: 30%, Neuro.: 38%, PT: 24% and PI: 38%. Pearson's Chi-squared test

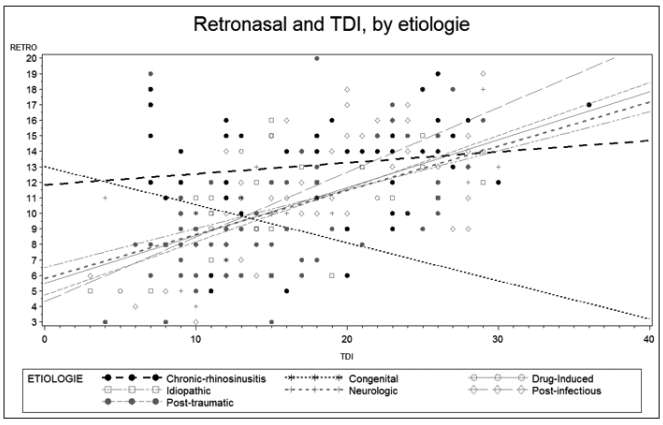

Figure 5. TDI vs retronasal scores

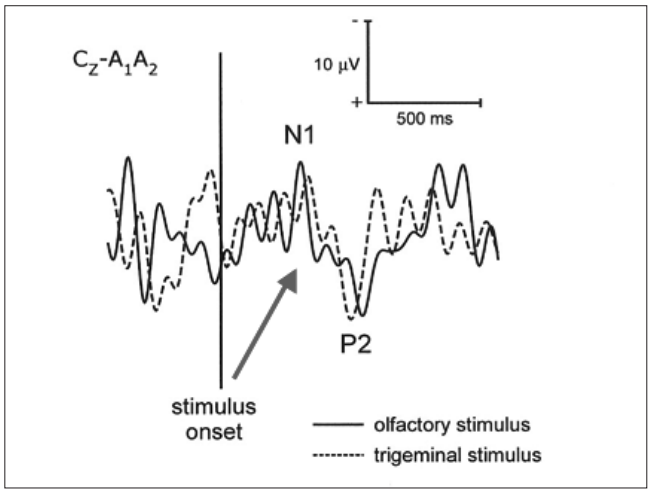

Figure 6. Shape and nomenclature of chemosensory event related potentials; Cz position recording referenced to A_1A_2 Complex N1-P2 Trigeminal stimulus; solid line (TERPs) Olfactory stimulus; dotted line (OERPs).

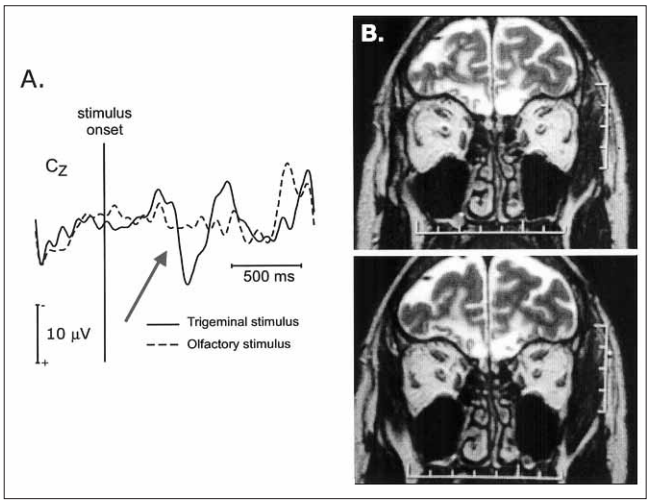

Figure 7. 50-years old woman with major post-traumatic olfactory loss (with Parosmia). Endoscopic endonasal examination was unremarkable TDI score: 3+3+4 = 10/48 (functional anosmia). Retroolfaction score: 6/20 (Decreased score).
A; Chemosensory ERP (Cz) with absence of olfactory response to orthonasal stimulation with 2-Phenyl Ethyl Alcohol (dotted line) and evoked response to trigeminal stimulation with CO_2 (solid line) B-C; Coronal T2-weighted image showing major traumatic injury in the olfactory bulb area (basifrontal sequellae).

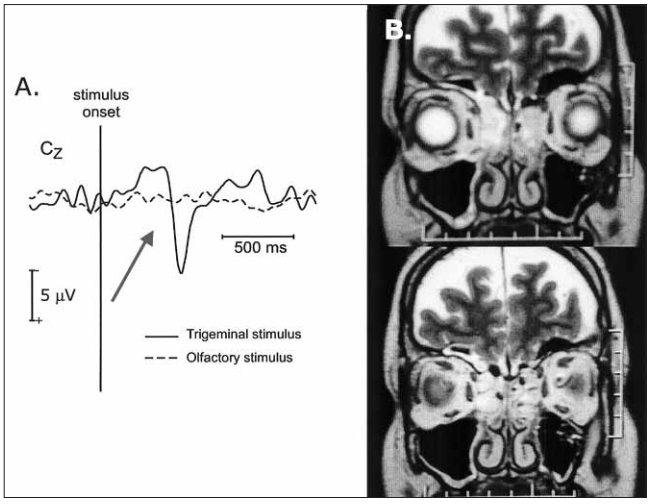

Figure 8. 52-years old woman with nasal polyposis (no parosmia) Endoscopic endonasal examination revealed nasal polyposis stage II TDI score: 2+8+7 = 17/48 (hyposmia) Retroolfaction score: 17/20 (Normal score) A; Chemosensory ERP (Cz) with absence of olfactory response to orthonasal stimulation with 2-Phenyl Ethyl Alcohol (dotted line) and evoked response to trigeminal activation with CO_2 stimulus (solid line). B-C; Coronal T2-weighted image showing ethmoid inflammation corresponding to nasal polyposis with no specific disease in the olfactory bulb area.

for presence of OERPs between the different subgroups of patients was not significant: DF = 6, X-squared = 10.07, p = 0.12. However, it was statistical significant if we consider presence of OERPs vs hyposmic/anosmic patients: DF 2, X-squared = 77.52, $p < 0.0001$. Actual prevalence of OERPs in anosmics and hyposmics patients was respectively 2.7% and 55,1%. Mean TDI value where an OERPs was present was 24.19 (SD ± 7, 95%; confidence interval 22.9-25.4). Mean retronasal scores where an OERPs was recorded was 13.2 (SD ± 3, 95%; confidence interval 12.8-14.5).

Statistical testing showed significant differences when comparing TDI (DF: 1, F = 197.01, Pr > F; $p < 0.0001$) and retronasal scores (DF: 1, F = 47.96, Pr > F; $p < 0.0001$) between patients with or without OERPs. Figure 6 shows normal electrophysiological recording after olfactory and trigeminal stimuli with the classical N1-P2 waveform. Figures 7 and 8 demonstrate typical examples for which OERPs could not be recorded, but well TERPs in patients with posttraumatic olfactory disorder and CRS.

DISCUSSION

The most salient results of this study are (i) patients with olfactory dysfunction may be investigated in a clinical situation with psychophysical testing and electrophysiological studies with a very limited number of patients who did not complete the evaluation (ii) psychophysical studies demonstrate different scores regarding the cause of the olfactory dysfunction, (iii) OERPs are recorded in one third and TERPs in almost every patient with olfactory disorder, and (iv) presence or absence of OERPs is not different regarding the aetiology of the olfactory disorder. Psychophysical testing may be viewed as a semi-objective method and CSERPs as a more objective method to assess olfactory performances. These two methods have been demonstrated to be useful and feasible in a rhinology clinic for patients with olfactory dysfunction. This helps to categorize the patients, to obtain basal values and information before starting a treatment or to assess the prognosis of spontaneous recovery.

Assessment of the orthonasal olfactory function is performed by presenting odours with bottles, pens, or microencapsulated "scratch and sniff" devices. Different tests have been validated: the UPSIT test, which is based on "scratch and sniff" devices (University of Pennsylvania Smell Identification Test [1]), the CCCRC-test (Connecticut Chemosensory Clinical Research Center), which is based on squeeze bottles [10], and the German "Sniffin' Sticks" Test, which is based on felt tip pens impregnated with odorant [2]. Other validated testing methods include the Scandinavian odour-identification-test (11), a Swiss smell diskettes test [12] and the Spanish smell test-24 (BAST-24) [13]. Orthonasal olfactory testing of odour identification is frequently based on a forced-choice paradigm where an odour is presented to the subject at a supra-threshold concentration while a list of verbal or visual descriptors is presented. Subjects then select the verbal item which best describes the odour. The output of such identification tests is the sum of correctly identified items.

Psychophysical olfactory testing requires the cooperation of the subject or patient. Therefore, these methods are not applicable in unconscious or uncooperative subjects. A large amount of the testing relies on the subject's verbal abilities. Furthermore, results from psychophysical tests may sometimes be difficult to interpret within a medico-legal context. Indeed, results may be subject to patient response biases. Nevertheless, scores lying well outside of the normal distribution of data may serve as an indication of possible malingering. Psychophysical measurements may contribute to the diagnosis of a quantitative olfactory deficit such as anosmia or hyposmia. However, none of these techniques seems to be valuable for the diagnosis and investigation of qualitative olfactory dysfunctions such as parosmia and phantosmia.

Some interesting findings were supported by this study. First of all, it seems that patients with a slow onset of their olfactory dysfunction, those from the chronic rhinosinusitis subgroup, have a significant higher orthonasal and retronasal score than most of the other subgroups. Moreover, correlation between TDI and retronasal scores is strong for idiopathic, post-medication, post-traumatic and post-infection olfactory dysfunction and not for chronic rhinosinusitis patients (congenital subgroup is probably too small to draw any conclusion). Therefore, we can speculate that for patients with a slow onset of olfactory dysfunction, the retro-olfaction seems to be constantly adapted following the loss of the orthonasal route leading to the fact that correlation between these two scores is absent.

In a clinical setting, the recording of chemosensory ERPs constitutes an interesting electrophysiological approach to the assessment of both olfactory and trigeminal chemosensory function. At present, partly due to the lack of normative data and to significant inter-individual differences, chemosensory ERPs are mostly interpreted in a dichotomous manner: they are either present (normal) or absent (pathological) [14-16]. Selection of CSERP component is based on the morphology of the averaged waveform, on the corresponding component found at others electrodes recording sites, on latency and amplitude criteria found in database of patients and controls and when averaged waveforms are clearly distinguishable from the background noise.

CSERPs may be considered as direct electrophysiological correlates of the cortical activity, which is elicited by chemosensory stimulation [6]. The amplitude of CSERPs may be correlated to both the quantity and the synchronicity of the underlying cortical activity. The latency of the different CSERPs may reflect the speed of information processing. As compared to psychophysical methods, the recording of CSERPs does not require the subject's cooperation. Even though CSERPs are subject to attentive and cognitive factors, the fact that their presence is not subject to possible patient response bias constitutes an important argument, especially when assessment of olfactory function is conducted within a medicolegal context.
CSERPs mainly consist of a large negative component (often referred to as N1) whose peak typically occurs between 300 and 600 ms after stimulus onset. It is followed by a large positive component, often referred to as P2, and peaking between 400 and 800 ms after stimulus onset. This positive component is often described as a complex comprising two distinct peaks [14,15].
CSERP components are significantly modulated by a number of factors, which include: stimulus-related variables (e.g.: stimulus intensity, stimulus duration) and subject-related variables (e.g.: sex, age, cognitive status) [17-20]. The CSERPs elicited in women and in young subjects are often of greater amplitude and shorter latency than those recorded in men and older people. Finally, both the negative and the positive component of TERPs are, in general, of greater amplitude than that of OERPs. Furthermore, while TERPs are maximally recorded at the vertex (electrode position Cz), OERPs often display a more parietal distribution, maximal amplitudes being recorded at electrode position Pz. It is often assumed that the early N1 component reflects brain activity related to the processing of exogenous stimulus characteristics while the later P2 component reflects more endogenous brain processes, possibly related to the novelty or significance of the stimulus [18].

As the identification of CSERPs components relies on the presence of an adequate signal-to-noise ratio, the absence of distinguishable components must be interpreted with caution, and should certainly not be considered as necessarily reflecting anosmia if considered after olfactory stimulus [21]. It has been demonstrated that the probability to detect a reproducible OERPs is greater than 50% for patients categorized as hyposmic using psychophysical testing [21]. In the absence of OERPs components, two issues should be considered. The first is

whether TERPs components may be consistently recorded. Indeed, the presence of normal responses to trigeminal stimulation constitute evidence against the possibility of technical problems during the recording. The second is to determine whether the psychophysical assessment of olfactory function corroborates the electrophysiological findings. If the OERPs is absent and the psychophysical testing lies within normal ranges, the possibility of a methodological concern (e.g. odorant present in the normally odourless background airflow, often resulting from a poorly ventilated room), or a high level of background noise contaminating the EEG recording (e.g. background muscular activity, eye blinks, alpha-rhythm) must be considered. If the OERPs are present but the psychophysical testing lies within the range of functional anosmia, a possible lack of collaboration or malingering during the psychophysical evaluation must be considered.
Finally, if both OERPs and TERPs are present, and if psychophysical testing indicates hyposmia, one may conclude that the olfactory function is diminished. However, and based on past clinical experience, the presence of preserved OERPs components constitutes an indication of further recovery of olfactory function.

When considering the presence or absence of OERPs and the orthonasal and retronasal scores, it should be pointed out that this study corroborates the clinical finding of another study based on a smaller cohort of patient.
In fact, recording of OERPs seems to be possible and superior to the dichotomous statistic chance of 50% when patients yield an orthonasal score of 24 (50% of the maximal score that could theoretically be obtained) [22].

When evaluating patients presenting with an olfactory disorder, it is important to take into consideration the fact that the olfactory system and the chemosensory trigeminal system interact. Sensations, which result from olfactory activation, are odorous sensations. Sensations that result from trigeminal activation include tactile sensations, burning (mostly involving C-fibres), stinging (mostly involving A-δ-fibres), cooling, or warming. Intact trigeminal and olfactory sensitivity are essential for olfactory acuity [23,24]. There is a mutual interaction between the two systems that leads to a decreased of trigeminal sensitivity when olfactory acuity is decreased and vice-versa [25,26]. The presence of normal TERPs or demonstration of subtle variation into the TERPs such as increased latencies of peaks combined with the absence of OERPs is thus a strong indication of the presence of an olfactory dysfunction.

CONCLUSION

CSERPs recording is a valid technique for the assessment of olfactory function. As compared to psychophysical testing, it is less subject to patient bias. Patients with complete olfactory loss typically exhibit reproducible responses to trigeminal chemosensory stimulation but not to olfactory stimulation. Nevertheless, the absence of consistent chemosensory ERP responses should be interpreted with caution, and must take into consideration the patient's history, the results from other tests of chemosensory function, and additional clinical examinations including nasal endoscopy and MRI imagery.

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