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ORIGINAL STUDY

Difficulties of olfactometric evaluation in patients accusing smell disorders after head trauma

Gabriela-Violeta Melinte[1,2], Codrut Sarafoleanu[1,2]

[1]Center of excellence for research of sensorial and sensitive disorders, study of infecto-inflammatory, tumoral and obstructive aero-digestive pathology (CESITO), ENT&HNS Department, "Sfanta Maria" Clinical Hospital, Bucharest, Romania

[2]"Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania

ABSTRACT

Head trauma is considered to be the third cause of olfactory function disorders. Olfactometric assessment in patients accusing anosmia following head injury produced by car accident or aggression is important, because most of them are involved in law trials in order to obtain financial compensations from the author. It is compulsory to use both subjective and objective olfactory evaluation methods combined with a detailed anamnesis, a complete ENT examination and a good cranio-facial imaging (computed tomography or MRI) in order to exclude malingerers and to obtain an accurate diagnosis.

"Sfanta Maria" ENT Department from Bucharest is the only center in Romania where the olfactory function in completely investigated. We use chemosensory (Snap and Sniff Test and n-Butanol Dynamic Olfactometry) and electrophysiological tests (electric olfactory evoked potentials of the olfactory bulb).

Unfortunately, we confront with a series of difficulties in what concerns the smell function evaluation: 1) there is scarce information in the literature regarding the olfactory electric evoked potentials; 2) the electric olfactory evoked potentials register only the electrical activity in the olfactory bulb; 3) in case of olfactory impairment medically confirmed, we cannot establish a cause-effect relationship between the disturbance and the event; 4) the most accurate electrophysiological assessment method currently available in Europe is the time-frequency analysis of chemosensory event-related potentials, but we do not dispose of the necessary equipment yet; 5) sometimes patients do not give us the informed consent for a complete olfactory evaluation.

KEYWORDS: anosmia, head trauma, dynamic olfactometry, Snap and Sniff Test, electric olfactory evoked potentials

INTRODUCTION

Head trauma is reported in the literature to be one of the commonest factors damaging the olfactory function together with chronic rhinosinusitis and upper respiratory tract infections. Smell has an important significance in our lives, its affection causing severe repercussions leading even to depression and somatic health problems[1]. It is important to establish an evaluation protocol in order to discover the cause of the olfactory dysfunction, so an adequate treatment could be initiated in the interest of rising patients' quality of life.

The olfactory mucosa, also called the olfactory neuroepithelium, can be found in the upper part of the nasal fossae and its surface is estimated to 2.5 cm^2 for each nostril. It covers the superior part of the nasal septum, the superior area of the middle turbinate, the superior turbinate and the cribriform plate of the ethmoid bone[2]. The olfactory neuroepithelium contains the olfactory receptor neurons (ORNs) , supporting cells, basal cells and the duct of Bowman's glands.

Corresponding author: Gabriela-Violeta Melinte, Center of excellence for research of sensorial and sensitive disorders, study of infecto-inflammatory, tumoral and obstructive aero-digestive pathology (CESITO), ENT&HNS Department, "Sfanta Maria" Clinical Hospital. 37-38 Ion Mihalache Blvd., District 1, Bucharest, Romania
e-mail: violeta_melinte@umfcd.ro
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The ORNs are bipolar cells, their dendrites being found in the olfactory cleft. They present cilia on their surface, which take over the odor particles and transport them via the ORN axons, passing through the cribriform plate to the olfactory bulb where they synapse in the glomerulus - the only station between the olfactory mucosa and the cortex. From the glomerulus, the information is then transmitted to the primary olfactory cortex (piriform cortex, uncus, entorhinal cortex, the anterior olfactory nucleus, the olfactory tubercle and nucleus, the periamygdaloid cortex) and finally the information is projected to the thalamus, the hypothalamus, the amygdala, the insular cortex, the hippocampus and the orbitofrontal cortex[3].

According to a literature review published by Nordin in 2008, head trauma is the third most common cause of olfactory loss[4], but we have to mention that there are a few situations that impede an accurate estimation of smell impairment incidence caused by head trauma: in emergency services there is no special preoccupation for olfactometric assessment, head trauma evaluation being the first concern of the doctors, especially if there is neurological affection that require immediate attention and medical/ surgical treatment; usually, patients do not realize spontaneously the lack of smell sense[5]. According to Swann[6], head trauma is most commonly produced by fall in 61% of cases, car accidents in 20% and assaults in 13% of patients.

MATERIAL AND METHODS

A number of 49 patients complaining of smell loss following head trauma produced by car accident or by human aggression and with medico-legal involvement were evaluated in the "Sfanta Maria" ENT Department in order to objectify their olfactory disorder.

Our evaluation protocol is based on a thorough patient history, clinical ENT evaluation, culture of nasal secretions, nasal endoscopy (to identify the presence of an anomaly that could cause patient's anosmia - anatomical anomalies, inflammation of the olfactory mucosa, intranasal tumors, etc.), imaging examination (cranio-facial computed tomography or MRI) and olfactometric assessment (Snap And Sniff Test, dynamic olfactometry using n-Butanol for threshold detection and olfactory electric evoked potentials to establish if there is electrical activity in the olfactory bulb).

Imaging examination, especially head MRI, is very important from two points of view: it can detect a brain lesion that can lead to smell impairment and it can measure the volume of the olfactory bulb. It was demonstrated by Thomas Hummel et al.[7] that, in head trauma, neurodegenerative disorders (Alzheimer disease, Parkinson disease), upper respiratory airways infections, psychiatric diseases and congenital anosmia, the volume of the olfactory bulb is decreased and this explains the anosmia or hyposmia of these patients. It was also stipulated in the literature, by C. Huart et al.[8], that the olfactory bulb has the capacity of changing its dimensions, this particularity being entitled plasticity[9,10].

Snap and Sniff Threshold Test, produced by Sensonics, uses 20 smell "wands". Fifteen contain half-log dilutions ranging from 10^{-2} (strongest) to 10^{-9} (weakest) concentrations of Phenyl ethanol, whereas the other five contain no odor. Normative data, published by Richard L. Doty, consider a value >2.625 log vol/vol suggestive for an olfactory affection[11].

Dynamic olfactometry is performed using the TO8 olfactometer produced by Olfasense. It uses different dilutions of n-Butanol in order to find the smell threshold of the evaluated patients.

Olfactory electric evoked potentials are registered with the Natus Nicolet device. The olfactory mucosa is stimulated using a bipolar electrode introduced under endoscopic control in the olfactory cleft. 100 stimulations for each nostril are registered (0.5 ms per stimulation and the applied current intensity 2mA). Five cutaneous electrodes are placed in the frontal and temporal regions, one reference electrode in the fronto-parietal area and one ground electrode.

In Romania, the number of patients accusing olfactory function disorders after head trauma produced by car accident (most of them pedestrians hit by cars on the crosswalk) or human aggression is increasing because of the financial implication.

"Sfanta Maria" ENT Department is the only center in Romania where the olfactory function can be evaluated using chemosensory tests (dynamic olfactometry, Snap and Sniff Test) and electrophysiological investigation (electric olfactory evoked potentials).

We evaluate patients with smell impairment following upper respiratory tract infections, chronic rhinosinusitis with or without nasal polyps, head trauma or idiopathic disorders. All the patients accusing anosmia after head trauma are referred to our clinic by forensic doctors from "Mina Minovici" National Legal Medicine Institute from Bucharest and from other Legal Medicine Departments in Romania, because all of them are involved in penal trials, they being the victims. Our medical evaluation and medical report regarding the olfactory function is very important for case resolution.

In these situations, it is mandatory to detect malingerers. In order to do so, an objective evaluation method of the olfactory function is needed, because the chemosensory tests are dependent on patient's reaction and they can lead the answer to a convenient situation for them.

RESULTS

Patients with head trauma background evaluated in our clinic for anosmia can be divided into three categories: 1. very possible malingerers; 2. patients with cerebral lesions and with medical confirmation of the anosmia; 3. patients with visible injuries, but without electrophysiological confirmation of the olfactory disorder.

To exemplify the first category, of the very possible malingerers, we bring into discussion the case of a 50 -year-old male, who was accusing posttraumatic anosmia, arisen following physical aggression. He was the victim in a law trial. The ENT evaluation found no pathological modification into the nose, but the CT scan showed a traumatic lesion of the cribriform plate.

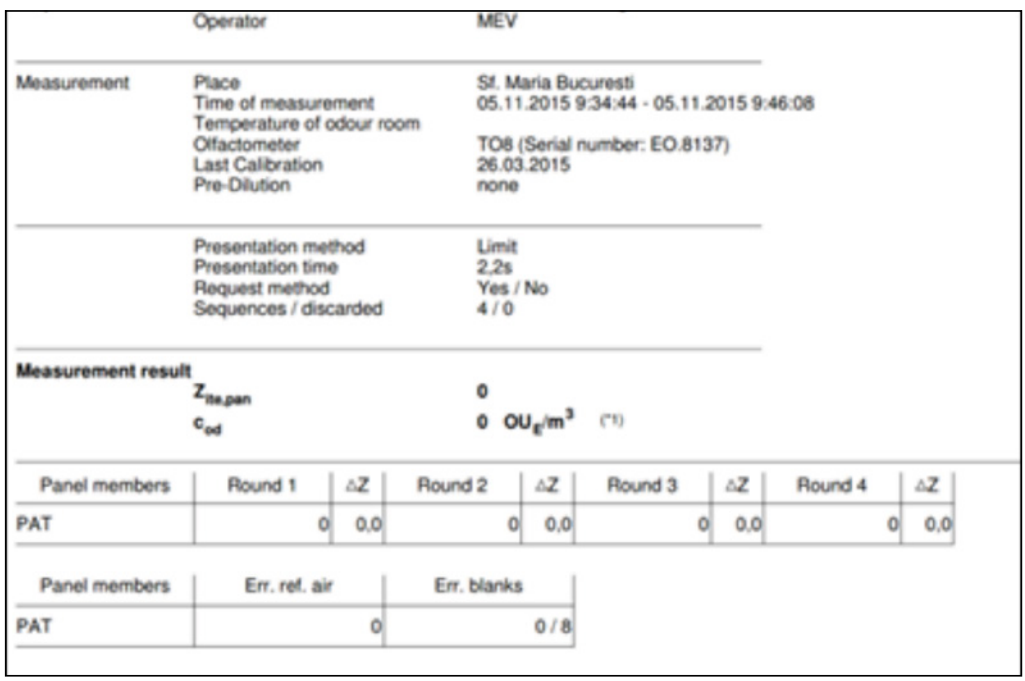
Dynamic olfactometry was performed, with no response registered (Figure 1). Not only did he not consent to perform the registration of electric olfactory evoked potentials, but he also showed a verbal aggressiveness, because he could not understand why him, as a victim in the on-going law trial, was supposed to endure so many investigations in order to objectivate his suffering.

In this situation malingering might be suspected, but it cannot be pointed out since the patient did not accept the olfactory evaluation to be completed.

Regarding patients with serious head trauma, especially following car accidents, the areas most frequently injured were the frontal lobe, the fronto-temporal region, the occipital bone and, in one case, an olfactory bulb damage was reported.

As we mentioned earlier in this article, in some patients with head trauma, the smell impairment was confirmed by specific tests, in others it was not. For example, a 41-year-old male, who suffered a second degree cranio-cerebral trauma after human aggression and who was complaining of anosmia appeared right after the event, was referred to our department by the National Legal Medicine Institute from Bucharest in order to establish if his complaint was real or not. Even though the aggression had taken place 4 years before the olfactometric evaluation, the radiological aspect was stationary on a new IRM examination performed six months before admission in our department. The radiologist described frontal bilateral posttraumatic modifications persistent compared to the initial examination (Figure 2a,b). In this patient, both subjective and objective assessment (Figures 3, 4) confirmed the presence of anosmia. It is very possible for the smell impairment to have been a consequence of the head trauma given the radiological aspect, with visible modifications in the central olfactory area.

It is not mandatory for anosmia to appear in case of brain lesion detection. For example, in the case of a 23-year-old young woman, with sequelar lesions in bilateral antero-inferior frontal regions (right>left) with olfactory bulb involvement, the subjective assessment was suggestive for anosmia (Figures 5, 6), but after olfactory evoked potentials registration we concluded that there could be found electric activity in the olfactory bulb (Figure 7).



	Operator	MEV
Measurement	Place	St. Maria Bucuresti
	Time of measurement	05.11.2015 9:34:44 - 05.11.2015 9:46:08
	Temperature of odour room	
	Olfactometer	TO8 (Serial number: EO.8137)
	Last Calibration	26.03.2015
	Pre-Dilution	none
	Presentation method	Limit
	Presentation time	2,2s
	Request method	Yes / No
	Sequences / discarded	4 / 0
Measurement result		
	$Z_{ite,pan}$	0
	c_{od}	0 OU_E/m^3 (*1)

Panel members	Round 1	ΔZ	Round 2	ΔZ	Round 3	ΔZ	Round 4	ΔZ
PAT	0	0,0	0	0,0	0	0,0	0	0,0

Panel members	Err. ref. air	Err. blanks
PAT	0	0 / 8

Figure 1 Dynamic Olfactometry result showing subjective anosmia.

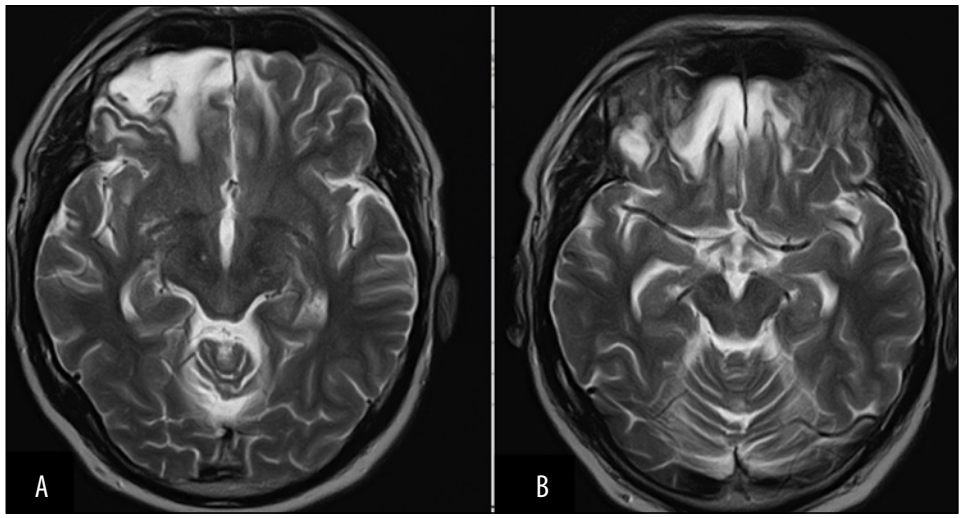
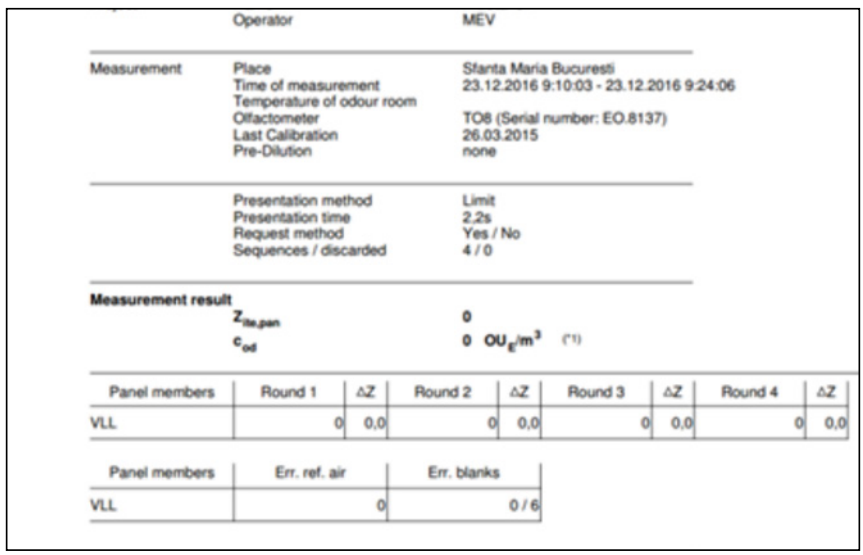


Figure 2 **A,B.** Head MRI (axial sections) showing posttraumatic lesions in both frontal lobes affecting the olfactory area.



	Operator	MEV
Measurement	Place	Sfanta Maria Bucuresti
	Time of measurement	23.12.2016 9:10:03 - 23.12.2016 9:24:06
	Temperature of odour room	
	Olfactometer	TO8 (Serial number: EO.8137)
	Last Calibration	26.03.2015
	Pre-Dilution	none
	Presentation method	Limit
	Presentation time	2.2s
	Request method	Yes / No
	Sequences / discarded	4 / 0
Measurement result		
	$Z_{ite,pan}$	0
	c_{od}	0 OU_E/m^3 (*1)

Panel members	Round 1	ΔZ	Round 2	ΔZ	Round 3	ΔZ	Round 4	ΔZ
VLL	0	0,0	0	0,0	0	0,0	0	0,0

Panel members	Err. ref. air	Err. blanks
VLL	0	0 / 6

Figure 3 n-Butanol Dynamic olfactometry showing subjective anosmia.

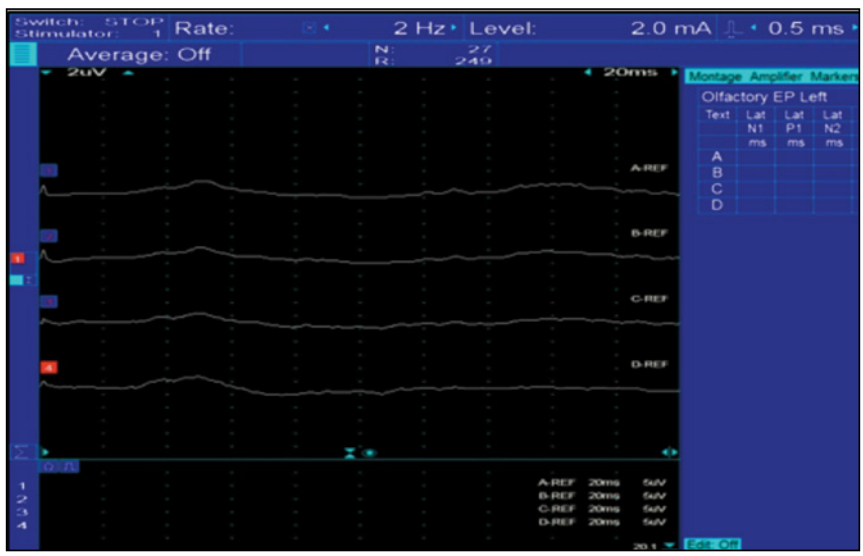


Figure 4 Electric olfactory evoked potentials registration showing absence of electric olfactory evoked potentials.

Laboratory		Spitalul Clinic "Sfanta Maria" Bucuresti Clinica ORL Centrul de excelenta pentru cercetarea mecanismelor tulburarilor senzitiv-senzoriale si studiul patologiei inflamator-infectioase, tumorale si obstructive a cailor aerodigestive superioare/CESITO
Sample		**n-Butanol**
Project	Name Operator	
Sampling	Time Place Pre-Dilution	18.09.2017 15:20:31 Clinica ORL Sfanta Maria none
Measurement	Place Time of measurement Temperature of odour room Olfactometer Last Calibration Pre-Dilution	Clinica ORL - Spitalul Clinc "Sfanta Maria" 18.09.2017 15:27:05 - 18.09.2017 15:35:42 TO8 none
Measurement result	$Z_{ITE,pan}$ c_{od}	**0** **0** OU_E/m^3 (*1)

Panel members	Round 1	ΔZ	Round 2	ΔZ	Round 3	ΔZ	Round 4	ΔZ
MAP	0	0,0	0	0,0	0	0,0	0	0,0

Panel members	Err. ref. air	Err. blanks
MAP	1	0 / 2

Figure 5 Dynamic olfactometry showing subjective anosmia.

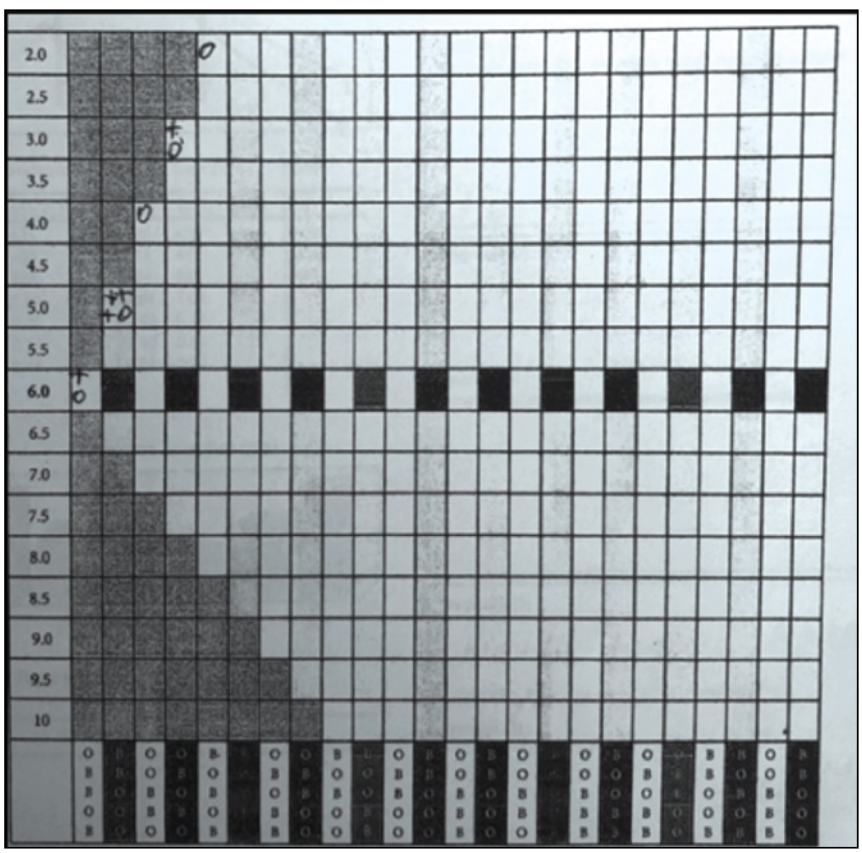


Figure 6 Subjective anosmia at the Snap and Sniff Test.

Figure 7 Electric olfactory evoked potentials registration showing presence of electric activity in the olfactory bulb.

DISCUSSIONS

The olfactometric evaluation is not easy to be interpreted, especially in medico-legal cases. We confront with a series of difficulties, because although there are a lot of articles in the literature about olfaction and its assessment, there is no evaluation method discovered yet that can establish a precise diagnosis.

When we deal with patients referred from Legal Medicine Departments, the prosecutors ask for certain answers to a few questions: 1. Is there a cause-effect relationship between the event and the olfactory impairment? 2. Is the anosmia reversible? 3. In case of subjective anosmia, but with electric activity in the olfactory bulb, is the patient considered a malingerer?

We have to mention that the cause-effect relationship between the accident/ aggression and the olfactory impairment cannot be established, because we do not know if the smell function was normal or not before the event. An exception here is represented by the cases of visible IRM lesions in the olfactory area that are mostly probably responsible for the anosmia.

Regarding the smell disorder reversibility, there is reported in the literature that 10% of the patients with smell loss after head trauma reported improvement[12]. In conclusion, we cannot estimate the recovery possibility of our patients.

We cannot consider a malingerer a patient with subjective anosmia, but with present electric activity in the olfactory bulb. Thomas Hummel[13] published an article in 2006 where he mentioned that the presence of the olfactory potential indicates normal smell function, but the absence of the olfactory potential is not pathognomonic for the olfactory impairment.

Currently, the most accurate electrophysiological assessment method available in Europe is the time-frequency analysis of chemosensory event-related potentials that offers an improved signal-to-noise ratio of the obtained EEG responses, in particular, following olfactory stimulation.

CONCLUSIONS

In conclusion, even though olfaction is studied for a very long time, there is no perfect evaluation method that can establish the diagnosis of anosmia.

Unfortunately, there are difficulties we confront with during smell function assessment: 1) there is scarce information in the literature regarding the olfactory electric evoked potentials; 2) the electric olfactory evoked potentials register only the electrical activity in the olfactory bulb and the absence of the olfactory potential is not defining anosmia; 3) in case of olfactory impairment medically confirmed, we cannot establish a cause-effect relationship between the disturbance and the event; 4) there is no possibility of knowing if the olfactory disorder is reversible or not; 5) sometimes patients do not give us the informed consent for a complete olfactory evaluation.

Conflict of interest: The authors have no conflict of interest.

Contribution of authors: All authors have equally contributed to this work.

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