Utility of magnetic resonance imaging in idiopathic olfactory dysfunction: structural findings and functional correlation

Original Article

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Article received on May 10, 2026.
Accepted for publication on August 3, 2026.

Abstract

Objectives: To characterize magnetic resonance imaging (MRI) findings in patients with suspected idiopathic olfactory dysfunction (IOD) and evaluate the correlation between olfactory bulb (OB) volume and olfactory function.
Study Design: Retrospective cross-sectional study.
Material and Methods: Sixty-one patients with IOD evaluated between 2018 and 2025 were included. Olfactory function was assessed using the Portuguese Smell Test. MRI of the olfactory tract was used for OB volumetric assessment and characterization of structural findings. Correlations between OB volume and olfactory function were analyzed using Spearman's coefficient.
Results: OB atrophy was the most frequent imaging finding (60.6%). MRI identified a specific underlying cause in 3.3% of cases. A positive trend was observed between mean OB volume and DIF score, without statistical significance (ρ=0.296; p=0.051).
Conclusions: MRI remains relevant in the evaluation of IOD, allowing identification of specific causes in selected cases. The absence of a significant correlation between OB volume and olfactory function reinforces the pathophysiological heterogeneity of IOD.

Keywords: olfactory dysfunction; olfactory bulb; magnetic resonance imaging; smell; anosmia

Introduction

Olfactory dysfunction (OD) may result from a range of etiologies, including sinonasal disease, toxin exposure, and post-infectious, post-traumatic, neurodegenerative, neuro-psychiatric, congenital, and iatrogenic causes.[1] However, in an estimated 16% to 24% of individuals, the cause of OD cannot be identified after appropriate investigation, and the condition is classified as idiopathic olfactory dysfunction (IOD).[1,2] This condition

is a diagnosis of exclusion, established based on a complete clinical history, nasal endoscopy, focused neurological examination, psychophysical olfactory assessment, and magnetic resonance imaging (MRI) of the olfactory tract.[1] The main role of MRI is to rule out structural intracranial disease, particularly neoplasms. However, there is no consensus in the literature regarding the cost-effectiveness of MRI in IOD, with the reported detection rates of clinically relevant structural disease ranging from 0.8% to 4.9%.[3,4] Furthermore, MRI enables structural assessment of the olfactory pathway, including olfactory bulb (OB) volumetry, which has potential diagnostic and prognostic value.[1] Some studies have demonstrated a positive correlation between the OB volume and olfactory function in normosmic individuals and in patients with OD of different etiologies, reflecting mechanisms of plasticity of the olfactory pathway.[1,5,6] However, its clinical application remains limited, partly due to the variability in volumetric analysis protocols, and it has not yet been studied in patients with IOD. This study aims to characterize the MRI findings in patients with suspected IOD and evaluate the correlation between OB volumetry and olfactory function as assessed by the Portuguese (PT)-Smell Test.

Materials and Methods

Study design and participants

This was a retrospective, cross-sectional study based on a medical record review of all the patients seen at a Smell Clinic between 2018 and 2025 who underwent MRI of the olfactory tract to rule out structural intracranial disease and assess OB volume. The inclusion criteria were: individuals aged over 17 years, OD documented by psychophysical olfactory testing, and a suspected idiopathic etiology, established by excluding other causes based on the clinical history and physical examination described above. Patients with incomplete medical records, olfactometry results, or imaging reports were excluded.

Olfactometry

The olfactory function was assessed using the PT-Smell Test (2017), a test validated for the PT population, comprising 23 odorants: 19 targeting the olfactory nerve (lavender, coffee, vanilla, clove, banana, garlic, cinnamon, mint, rose, bitter almond, strawberry, pine, pineapple, lemon, caramel, orange, coconut, peach, and chocolate), 3 targeting the trigeminal nerve (ammonia, mustard, and wine vinegar), and 1 odorless control.[7] For each odorant, the participants answered standardized questions assessing detection (DT), spontaneous identification (S_ID), and forced identification (F_ID), which together yield the overall PT-Smell Test score (the DIF score), calculated as the sum of DT, S_ID, and F_ID. According to the validated cutoff points, OD was defined as F_ID < 71.14%, S_ID < 40.67%, or DIF < 45.[8]

MRI protocol

MRI was performed on a high-field (3.0 T) scanner using a 64-channel head coil. The acquisition protocol for OB assessment included coronal T2-weighted sequences, 3D T2/FLAIR, and a high-resolution 3D turbo spin-echo volumetric T2 sequence with a voxel size of 0.2 × 0.2 × 0.6 mm and no interslice gap. Coronal images were acquired in planes perpendicular to the cribriform plate from the frontal sinus to the optic chiasm.

Data collection

Demographic variables included age and sex. OD-related variables included the duration of OD and PT-Smell Test components: detection, spontaneous identification, forced identification, and DIF score.

Radiological data were obtained from the MRI reports and included the OB volume (right, left, and mean bilateral OB volume) and presence of specific findings, classified by olfactory pathway involvement: nasal mucosa abnormalities (sinonasal disease); OB abnormalities (atrophy or aplasia); precortical abnormalities (excluding the OB); primary olfactory cortex abnormalities (piriform, periamygdaloid, and entorhinal cortices and

the cortical nucleus of the amygdala); and secondary olfactory cortex abnormalities (orbitofrontal cortex and insula). OB atrophy was defined as a unilateral volume of less than 58 mm^3 in individuals younger than 45 years and less than 46 mm^3 in those older than 45 years.[5] Additionally, potentially relevant brain findings were recorded, including signs suggestive of diffuse neurodegeneration.

Statistical analysis

Statistical analyses were performed using SPSS version 27. Continuous variables were assessed for normality with the Shapiro–Wilk test, and given their non-normal distribution, are presented as medians and interquartile ranges (P25–P75). Categorical variables are presented as absolute frequencies and percentages. The Spearman's correlation coefficient was used to assess the associations between continuous variables and the DIF score. Statistical significance was set at $p < 0.05$.

Results

Participant characteristics

A total of 61 patients with suspected idiopathic OD were included. The sample consisted predominantly of women (77%), with a median age of 61 years (IQR, 21). The median duration of OD was 2 years (IQR, 3). On the PT-Smell Test, median spontaneous identification was 24% (IQR, 30), median forced identification was 39% (IQR, 43), and the median DIF score was 35 (IQR, 58). The median OB volume was 26.0 mm^3 (IQR, 25.3) on the right, 26.5 mm^3 (IQR, 21.5) on the left, and 27.5 mm^3 (IQR, 18.8) for the mean bilateral OB volume (Table 1).

MRI findings

For the primary characterization of the sample, each patient was classified according to the most relevant imaging finding along the olfactory pathway. OB atrophy was the most frequent OD-related imaging finding, identified in 37 patients (60.6%). In 11 cases (18%), no olfactory pathway abnormalities were identified. Nasal mucosa abnormalities were the main finding in 9 individuals (14.8%), while OB aplasia, precortical leptomeningeal abnormalities, primary olfactory cortex atrophy, and secondary olfactory cortex atrophy were each identified in 1 individual (1.6%; Table 2). A descriptive analysis of all imaging findings (including coexisting findings within individual patients) revealed nasal mucosa abnormalities in 21 patients (34.4%), including inferior turbinate hypertrophy and inflammatory sinus disease. Signs suggestive of diffuse neurodegeneration were also identified in 9 cases (14.8%), as were other incidental findings not directly related to OD (Table 3).

Table 1
Demographic, olfactory, and imaging characteristics of the sample, n = 61

Variable	n (%)
Sex, n (%)	
Female	47 (77)
Male	14 (23)
Age, median (IQR), years	61 (21)
OD duration, median (IQR), years	2 (3)
Spontaneous identification, median (IQR), %	24 (30)
Forced identification, median (IQR), %	39 (43)
DIF score, median (IQR)	35 (58)
OB volume, median (IQR), mm^3	
Right OB	26.0 (25.3)
Left OB	26.5 (21.5)
Mean bilateral OB volume	27.5 (18.8)

Table 2
Primary classification of OD-related MRI findings, per individual, n = 61

Primary imaging finding	n (%)
No abnormalities	11 (18)
Nasal mucosa abnormalities	9 (14.8)
Precortical leptomeningeal abnormalities	1 (1.6)
OB atrophy	37 (60.6)
OB aplasia	1 (1.6)
Primary olfactory cortex atrophy	1 (1.6)
Secondary olfactory cortex atrophy	1 (1.6)

Table 3
Detailed characterization of MRI findings, n = 61

Imaging findings	n (%)
Related to OD	
No abnormalities	11 (18)
Nasal mucosa abnormalities Inferior turbinate hypertrophy Inflammatory sinus disease	21 (34.4) 11 (18) 10 (16.4)
Precortical leptomeningeal abnormalities Neurosarcoidosis involving the olfactory sulcus and crista galli	1 (1.6)
OB atrophy	37 (60.6)
OB aplasia Unilateral	1 (1.6)
Primary olfactory cortex atrophy Piriform cortex (temporal)	1 (1.6)
Secondary olfactory cortex atrophy Orbitofrontal cortex	1 (1.6)
Not related to OD	
Signs of diffuse neurodegeneration	9 (14.8)
Small vessel ischemic disease	8 (13.1)
Retrocerebellar arachnoid cyst	1 (1.6)
Pituitary macroadenoma	1 (1.6)

MRI identified a specific structural etiological diagnosis in 2 patients (3.3%): 1 case of neurosarcoidosis involving the olfactory sulcus and crista galli, and 1 case of unilateral OB aplasia diagnosed in adulthood (Table 3).

Correlation between OB volumetry and olfactory function

There was a trend toward a positive correlation between the mean bilateral OB volume and DIF score ($\rho = 0.296$; $p = 0.051$) although it did not reach statistical significance. No significant correlation was observed between the mean bilateral OB volume and OD duration ($\rho = -0.179$; $p = 0.205$; Table 4).

Discussion

The prevalence of OB atrophy observed in our sample (60.6%) is consistent with the values reported in the literature, which vary between 43.5% and 85.7% in patients with post-infectious and idiopathic OD, respectively.[9,10] These findings support the association between OD and structural OB changes described across different OD etiologies. The plasticity of the human olfactory system,

Table 4
Correlation between olfactory bulb volume, olfactory function, and OD duration, n = 61

Variables	p (Spearman)	p
Mean bilateral OB volume vs. DIF	0,296	0,051
Mean bilateral OB volume vs. OD duration	-0,179	0,205

characterized by continuous neurogenesis and synaptogenesis within the OB, may explain the volumetric reduction associated with prolonged olfactory sensory deprivation.[11] In this study, there was a trend toward a positive correlation between the mean bilateral OB volume and DIF score, although it did not reach statistical significance. Previous studies have demonstrated a significant association between OB volume and olfactory function both in normosmic individuals and in patients with OD of various causes.[5,6,10,12] However, the results regarding IOD remain inconsistent. Hummel *et al.* observed a correlation between OB volume and olfactory detection thresholds; however, no association with suprathreshold parameters was observed.[13] This may account for the absence of a significant correlation with the DIF score in our sample. The OB volume appears to reflect complex pathophysiological mechanisms that potentially differ among individuals with IOD. The literature suggests that OB volumetric reduction may result not only from the loss of peripheral sensory input (bottom-up), as occurs in post-infectious or post-traumatic etiologies, but also from central (top-down) mechanisms, including neurodegenerative or neuropsychiatric processes.[13] In this context, IOD may not represent a single entity but rather a heterogeneous group of conditions that have not yet been fully characterized, including subclinical inflammatory disease or the early stages of neurodegenerative diseases.[13,14] This hypothesis may be partially supported by the concomitant findings observed in our sample, including sinonasal abnormalities and signs suggestive of diffuse neurodegeneration.

Although the primary indication for MRI in IOD is ruling out structural intracranial disease, its diagnostic yield remains debated, with the reported detection rates between 0.8% and 4.9%.[3,4] In the population studied, MRI identified a specific cause in 3.3% of cases: neurosarcoidosis involving the olfactory sulcus and unilateral OB aplasia associated with a congenital malformation. These findings indicate that, despite the low overall detection rate, MRI may have a diagnostic impact in selected cases. No significant correlation was found between the OD duration and OB volume; this association has previously been documented only in individuals with post-infectious OD. [6] This difference may reflect the greater pathophysiological heterogeneity of IOD compared with post-infectious OD.

This study has some limitations, including its retrospective nature and relatively small sample size. In addition, the imaging assessment was based on MRI reports, without a systematic blinded review of the images or assessment of interobserver agreement. The clinical and pathophysiological heterogeneity of IOD as well as the potential incidental relevance of some imaging findings, may confound the interpretation of the results.

Conclusion

OB atrophy was the most frequent imaging finding in patients with suspected IOD. No significant correlation was found between OB volume and olfactory function or OD duration, underscoring the pathophysiological heterogeneity of this condition. Despite the low overall detection rate, MRI identified specific causes in selected cases and remains relevant in the assessment of IOD.

Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

Author Contributions

Rafael Pires: conceptualization, methodology, data collection, formal analysis, investigation, writing of the original draft, review and editing of the manuscript; **Vera Vaz Teixeira:** methodology and editing of the manuscript; **Ricardo Nelas:** data collection; **Jorge Dentinho:** review of the manuscript; Aldora Quintal: data collection; **Mário Santos:** methodology, data collection, and review of the manuscript; **Luís Antunes:** methodology, review, and editing of the manuscript.

Data Confidentiality

The authors declare having followed the protocols in use at their working center regarding patients' data publication.

Protection of humans and animals

The authors declare that the procedures were followed according to the regulations established by the Clinical Research and Ethics Committee and to the 2013 Helsinki Declaration of the World Medical Association.

Privacy policy, informed consent and Ethics Committee Authorization

The authors declare that they have written consent for the use of photographs of patients in this article.

Funding Sources

This work did not receive any contribution, funding or scholarship.

Availability of scientific data

There are no datasets available, publicly related to this work.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the authors used ChatGPT (OpenAI) to assist with language review, text reformulation, and the structural organization of the manuscript. After using this tool, the authors thoroughly reviewed and edited the content as necessary and take full responsibility for the content of the publication.

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