Original Article

# Radiological Evaluation of Covid-19 Anosmic Patients By MRI of The Olfactory Bulb and Computed Tomography of the Paranasal Sinuses

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## ABSTRACT

**Background:** COVID-19 related olfactory dysfunction as an isolated symptom or in conjunction with other respiratory symptoms has been increasingly recognized.

**Aim:** The aim of this study was to assess the olfactory cleft and the olfactory bulb in post COVID-19 anosmic patients with paranasal sinus CT, and MRI dedicated to olfactory bulb to detect possible mechanisms for post covid-19 olfactory dysfunction.

**Patients and Methods:** This prospective study including 20 patients presented between 2021 and 2022 to Otorhinolaryngology Department at El-Hussein University Hospital & El-sahel Teaching Hospital.

**Results:** In our study the mean right OBV (38.3 ± 12.03), the mean left OBV (35.6 ± 9.1), the mean right OSD (7.4 ± 0.83) & the mean left OSD (7.3 ± 0.9). As regard Primary olfactory cortex and visualized olfactory tracts, 19 patients (95%) were normal and 1 patient (5%) was abnormal (This patient showed bilateral asymmetrical increased signal intensity in FLAIR and T2 WIs within the primary olfactory cortices, more notable at the left side). As regard Nerve filiaa, 19 patients (95%) were normal and 1 patient (5%) was abnormal (This patient showed subtle thickening and clumped appearance of the left olfactory nerve filia).

**Conclusion:** This study results showed high percentage of olfactory bulb degeneration suggests that injury to olfactory neuronal pathways also take place, specifically in cases with sub-acute and chronic post COVID-19 olfactory dysfunction. MRI can be used to demonstrate olfactory injury in patients with COVID-19 which allow the diagnosis and prognosis prediction in patients with OD so we recommend MRI imaging in cases of olfactory dysfunction.

**Key Words:** Anosmic MRI; computed tomography, covid-19, olfactory bulb, paranasal sinuses.

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## INTRODUCTION

COVID-19 first detected in Wuhan, China in December 2019, fast spread across the globe, causing a pandemic affecting many countries around the world. The main manifestations of COVID-19 include fever, dry cough and dyspnea. Additionally, other manifestations such as constitutive, gastrointestinal or neurologic symptoms have also been reported, such as fatigue, headache, nausea, vomiting and myalgia.[1]

COVID-19 related olfactory dysfunction as an isolated symptom or in conjunction with other respiratory symptoms has been increasingly recognized. A recent meta-analysis identified 45% of COVID-19 patients had olfactory dysfunction. The olfactory dysfunction is sudden onset in the majority of cases and is usually a transient entity with a median time to recovery ranging between 1 and 3 weeks. No significant association with sinonasal symptoms was found.[2]

Magnetic resonance imaging (MRI) dedicated to olfactory nerves is a useful anatomical imaging modality for evaluation of olfactory dysfunction related to postviral infection, trauma, and neurodegenerative processes. A dedicated MRI study allows assessment of olfactory bulb volume, morphology,signal intensity, status of olfactory nerve filia, and signal intensity of primary olfactory cortex, which is helpful to differentiate between different etiologies and predict prognosis of olfactory function recovery.[2]

The aim of this study was to assess the olfactory cleft and the olfactory bulb in patients presenting with COVID-19 related anosmia with paranasal sinus CT, and MRI dedicated to olfactory bulb to detect possible mechanisms for post covid-19 olfactory dysfunction.

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## PATIENTS AND METHODS:

This prospective study including consecutive 20 patients presented to Otorhinolaryngology Department at El-Hussein University Hospital & El-sahel Teaching Hospital between 2021 and 2022.

Total number of patients were 20 patients with age ranged from 19 to 60 whith mean age (30.9 ± 10.7) ys. 11 males & 9 females. all patients presented with anosmia after COVID-19 infection.

This study was approved by ethical committee of Ear, Nose and Throat department, Faculty of Medicine, Al Azhar Univerity.

**Included subjects:** Patients with COVID-19 infection and olfactory dysfunction, COVID-19 infection was confirmed with a positive polymerase chain reactio (PCR) test from nasal and nasopharyngeal swabs.

**Excluded subjects:** Pediatric and pregnant patients, patients with history of head trauma, patients with preexisting smell and taste alterations, patients with allergic rhinitis and chronic rhinosinusitis and patients with history of nasal operations.

**Method of data collection:** Personal history then complete ENT medical history with a specific focus on olfactory dysfunction for its onset, course and duration, history about loss of taste, sinonasal symptoms (nasal congestion, rhinorrhea) were collected. Patients underwent complete ENT examination with detailed endoscopic examination of the nose and olfactory region.

### *All patients underwent:*

**CT Nose and PNS:** High-resolution paranasal sinus CT scan (160-slice,CT scanner, Toshiba, Aquilion Prime, Nasu, Japan) acquired to assess cribriform plates and nasal passage for obstructive causes. Additional reformatted images of olfactory cleft will created with small field of view with 0.4 mm section-thickness and 0.1 mm increment. Olfactory cleft aeration pattern was grouped as normal, partial or total opacification.

**MRI Olfactory bulb:** MRI Acquisition: All patients examined by MRI scanning using Philips Achieva 1.5 T (Philips, Netherlands). The ideal MRI scan short in duration and non strenuous for the patient and technician. It provides a high signal-to-nose ratio and consistent signal intensities throughout the scan. Additional conventional sequences for whole brain were obtained.

**MRI Evaluation:** Olfactory bulb volume: was calculated based on sum of sequential region of interest on consecutive slices.

Olfactory bulb morphology: Evaluated on high-resolution coronal T2 sections. Oval or inverted-J shape of olfactory bulbs was considered as normal . Multiple areas (≥2) of olfactory bulb contour lobulation, rectangular shape or atrophic appearance were considered as abnormal.

**Olfactory bulb signal intensity:** Assessed with contralateral gyrus rectus taken as the reference point. Hyperintense signal abnormality was assessed for its morphology either as diffuse or punctate focus.

**Primary olfactory cortex and visualized olfactory tracts:** are evaluated for presence of abnormal signal intensity on T2 and FLAIR images.

**Olfactory sulcus depth:** Measured on coronal T2 images, by drawing a line tangent to the inferior borders of gyrus rectus and medial orbital gyrus and measuring the depth to the deepest point of the olfactory sulcus.

**Olfactory nerve filiaa:** Assessed on sagittal T2-space images through the medial and lateral aspects of the bulb. Fine architecture of the filia with uniform distribution at regular intervals was considered as normal. Regions of focal thickening with nonuniform distribution (clumping) and thinning with scarcity of filia are considered as abnormal.

### *Statistical analysis:*

Recorded data was analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean± standard deviation (SD). Qualitative data were expressed as frequency and percentage.

## RESULTS:

This prospective study including consecutive 20 patients with post covid-19 olfactory dysfunction.

A total of 20 patients participated in this study. the mean age of patients was 30.9 ± 10.7 (range 19-60). there were 11 males (55%) and 9 females (45%).

Five patients presented with isolated olfactory dysfunction, 15 patients had covid -19 related symptoms. -Four patients had sinonasal symptoms in the form of rhinorrhea and/or nasal obstruction; remaining 16 patients did not report sinonasal symptoms. 11 patients presented with loss of taste, remaining 9 patients presented with anosmia only without loss of taste (Table 1).

**Table 1:** description of clinical data in all studied patients

| | | Studied patients (N = 20) | |
|---|---|---|---|
| Clinical data | Corona sym | 15 | 75% |
| | Other sym | 4 | 20% |
| | Loss of taste | 11 | 55% |

Mean time between the onset of olfactory dysfunction and evalution was 11.2 ± 6.9 months (range 2-24).

On paranasal sinus CT olfactory clefts showed normal aeration in 13 cases, partial opacification in 6 cases and were totally opacified in a single case (Table 2).

**Table 2:** description of CT of olfactory cleft in the studied patients

| | | Studied patients (N = 20) | |
|---|---|---|---|
| CT olfactory cleft | Normal | 13 | 65% |
| | Partial opacification | 6 | 30% |
| | Total opacification | 1 | 5% |

**Olfactory bulb volume & sulcus depth:** The mean volume of right side OB volume was 38.3 ± 12.03 mm with minimum volume of 17.3 mm and maximum volume of 57.2 mm. As regard left side OB volume, the mean volume of all studied patients was 35.6 ± 9.1 mm with minimum volume of 19.5 mm and maximum volume of 52.8 mm (Figure 1).

The mean depth of right side OB sulcus depth was 7.4 ± 0.83 mm with minimum depth of 6.04 mm and maximum depth of 9.1 mm as regard left side OB sulcus depth, the mean depth of all studied patients was 7.3 ± 0.9 mm with minimum depth of 5.7 mm and maximum depth of 8.7 mm (Figure 2).

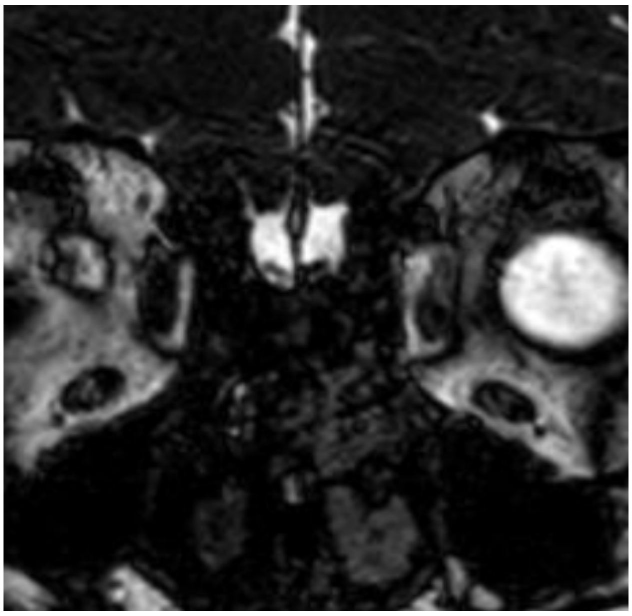

**Fig. 1:** Coronal T2 MRI demonstrates olfactory bulb of male pt 40 ys old shows bilateral decreased OB volume.

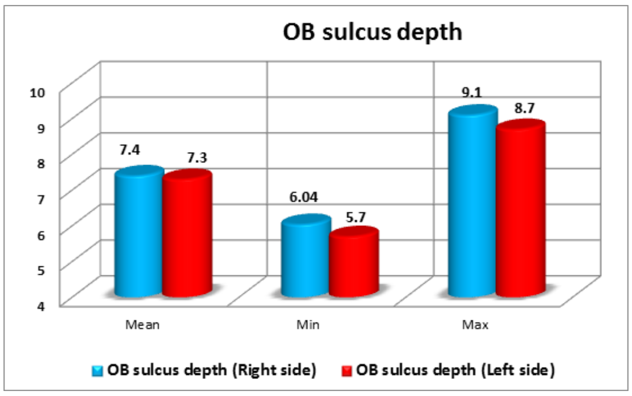


**Fig. 2:** description of OB sulcus depth in the studied patients

All patients showed normal OB morphology (Oval or inverted-J shape) & normal OB signal intensity (Figure 3). As regard Primary olfactory cortex and visualized olfactory tracts, 19 patients (95%) were normal and 1 patient (5%) was abnormal. This patient showed bilateral asymmetrical increased signal intensity in FLAIR and T2 WIs within the primary olfactory cortices, more notable at the left side (Figure 4). As regard Nerve filiaa, 19 patients (95%) were normal and 1 patient (5%) was abnormal. This patient showed subtle thickening and clumped appearance of the left olfactory nerve filia (Figure 5).

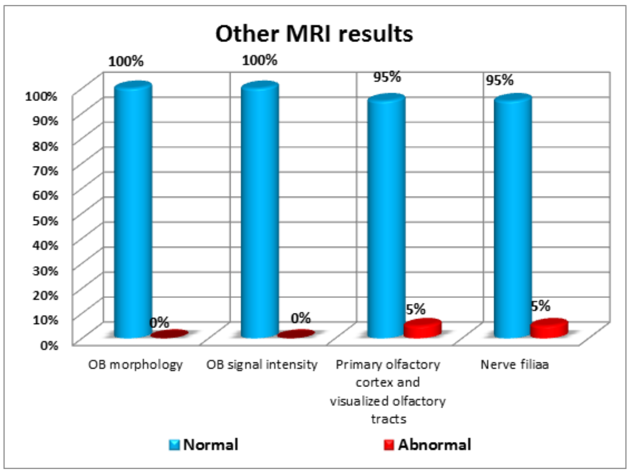


**Fig. 3:** description of other MRI results in the studied patients

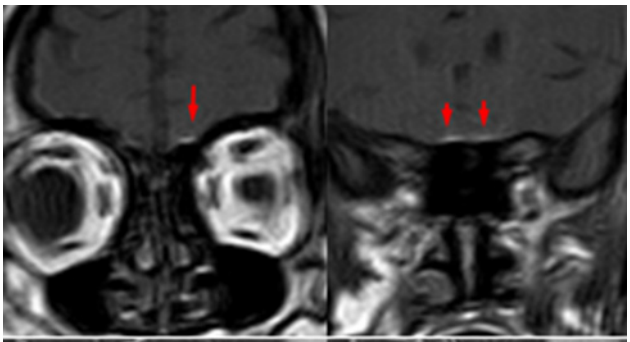

**Fig. 4:** MRI radiological assessment of olfactory pathway revealed bilateral asymmetrical increased signal intensity in FLAIR and T2 WIs within the primary olfactory cortices, more notable at the left side

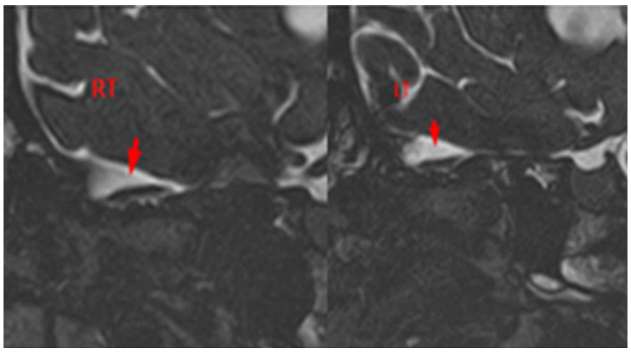


**Fig. 5:** Sagittal T2 MRI radiological assessment of olfactory pathway revealed: Subtle thickening and clumped appearance of the left olfactory nerve filia.

## DISCUSSION

The coronavirus disease 2019 (COVID-19) pandemic caused by severe acute respiratory syndromecoronavirus-2 (SARS-CoV-2) continues to spread at an exponential rate.[3]

IN this study 20 patients were included, all patients presented with confirmed covid -19&olfactory dysfunction. CT scan revealed 65% of patients with normal aeration of olfactory cleft, 30% with partial opacification and 5% with total opacification. MRI showed that most patient presented with decreased olfactory bulb volume and olfactory sulcus depth according to results of olfactory bulb volume (OBV) & olfactory sulcus depth (OSD) by **Buschhüter *et al*.**,[4] and **Cullu *et al*.**,[5]. In our study mean right OBV (38.3 ± 12.03), mean left OBV (35.6 ± 9.1), mean right OSD (7.4 ± 0.83) & mean left OSD (7.3 ± 0.9), **Buschhüter *et al*.**,[4] showed that normal OB volume for people >45 years the OB should have a minimum volume of 58 mm3; and for people <45 years the OB should have a minimum volume of 46 mm3. **Cullu *et al*.**,[5] results showed that The mean normal OBV values on both side were (91.17 ± 7.8 mm3)& the mean normal OSD on both sides (8.6 ± 0.8).

MRI can be used to evaluate post covid-19 olfactory dysfunction patients; it can be used to assess olfactory bulb, olfactory nerve filia and primary olfactory cortex.

**Galougahi *et al*.**,[6] case report reported normal olfactory bulb volume with normal signal intensity.

**Aragão *et al*.**,[7] in a case series demonstrated olfactory bulb abnormality as either microbleeding or abnormal enhancement on MR imaging.

**Chetrit *et al*.**,[8]. In a quantitative study of OB intensity (on coronal 3D - FLAIR sequence images with 2-mm section thickness) comparing patients with OD and normosmic COVID-19, the OB signal intensity in the OD group was significantly higher than that in the normosmic group.

**Moideen** *et al*.,[9] case reports showed bilateral olfactory Bulb Atrophy in Post–COVID-19 Parosmia.

**Politi *et al*.**,[10] showed subtle hyperintensity in bilateral olfactory bulbs accompanied by right gyrus rectus hyperintensity in a COVID-19 anosmia case. Control imaging 28-days later (when anosmia had recovered) showed complete resolution of cortical signal abnormality with decreased volume of the olfactory bulbs with partial resolution of the internal signal abnormality.

**Altunisik *et al*.**,[11] found significant decreases in the values of all investigated MR imaging parameters (right OBV, left OBV, total OBV, right OTL, left OTL, right OSD, and left OSD) in the COVID-19 group compared with the control group. In addition to an increase in focal intensity in 7 patients in the patient group.

The results of this study are consistent with most of the previous studies. We found significant decreases in the values of investigated MR imaging parameters: right olfactory bulb volume, left olfactory bulb volume, right olfactory sulcus depth and left olfactory sulcus depth. One patient showed bilateral asymmetrical increased signal intensity in FLAIR and T2 WIs within the primary olfactory cortices, more notable at the left side and one patient showed subtle thickening and clumped appearance of the left olfactory nerve filia.

According to this study post covid-19 olfactory dysfunction has sensorineural mechanism.

This study has some limitations. The number of patients participating in the study was relatively small. In addition, the decision not to evaluate patients with severe pulmonary and systemic infections and long disease durations may create concerns related to possible patient selection bias.

Another limitation is that patients' self-reported OD was accepted without performing objective smell-identification tests. We imaged patients after a median interval of 2-24 months from onset of olfactory dysfunction. So these imaging findings may reflect the subacute and chronic state of changes, rather than the acute changes. Assessment of olfactory bulb and olfactory filia for signal intensity and morphology requires extensive experience with high level of attention to details.

## CONCLUSION

This study results showed high percentage of olfactory bulb degeneration suggests that injury to olfactory neuronal pathways also take place, specifically in cases with sub-acute and chronic post COVID-19 olfactory dysfunction. MRI can be used to demonstrate olfactory injury in patients with COVID-19 which allow the diagnosis and prognosis prediction in patients with OD so we think that more MRI imaging in all stages of olfactory dysfunction in a large number of patients is important to clarify the certain mechanism of post covid-19 olfactory dysfunction.

## CONFLICT OF INTEREST

There are no conflicts of interest.

## REFERENCES

1. Naeini AS, Karimi-Galougahi M, Raad N, Ghorbani J, Taraghi A, Haseli S, *et al*. Paranasal sinuses computed tomography findings in anosmia of COVID-19. Am J Otolaryngol, 2020; 41(6):102636.

2. Kandemirli S G, Altundag A, Yildirim D, Sanli D E, Saatci O. Olfactory Bulb MRI and Paranasal Sinus CT Findings in Persistent COVID-19 Anosmia. Academic Radiology, 2021; 28, No 1.

3. Yan CH, Faraji F, Prajapati DP, Boone CE, DeConde AS. Association of chemosensory dysfunction and COVID-19 in patients presenting with influenza-like symptoms. Int Forum Allergy Rhinol, 2020;10(7):806-13.

4. Buschhüter D, Smitka M, Puschmann S, Gerber JC, Witt M, Abolmaali ND, *et al*. Correlation between olfactory bulb volume and olfactory function. Neuroimage: 2008; 42(2):498-502.

5. Çullu N, Yeniçeri İÖ, Güney B, Özdemir MY, Koşar İ. Evaluation of olfactory bulbus volume and olfactory sulcus depth by 3 T MR. Surg Radiol Anat. 2020; 42(9):1113-8.

6. Galougahi M K, Ghorbani J, Bakhshayeshkaram M, Naeini A S, Haseli S. Olfactory Bulb Magnetic Resonance Imaging in SARSCoV- 2-Induced Anosmia: The First Report. Academic Radiology, 2020; 27(6).

7. Aragão MFVV, Leal MC, Cartaxo Filho OQ, Fonseca TM, Valença MM. Anosmia in COVID-19 Associated with Injury to the Olfactory Bulbs Evident on MRI. AJNR Am J Neuroradiol 2020; 41(9):1703-6.

8. Chetrit A, Lechien JR, Ammar A, Chekkoury-Idrissi Y, Distinguin L, Circiu M, *et al*. Magnetic resonance imaging of COVID-19 anosmic patients reveals abnormalities of the olfactory bulb: Preliminary prospective study. J Infect 2020; 81(5):816-46.

9. Moideen S, Innisai A, Uvais NA. Bilateral Olfactory Bulb Atrophy in Post-COVID-19 Parosmia. Prim Care Companion CNS Disord. 2022;24(4):22cr03300.

10. Politi LS, Salsano E, Grimaldi M. Magnetic Resonance Imaging Alteration of the Brain in a Patient with Coronavirus Disease 2019 (COVID-19) and Anosmia. JAMA Neurol. 2020; 77(8):1028-9.

11. Altunisik E, Baykan AH, Sahin S, Aydin E, Erturk SM (): Quantitative Analysis of the Olfactory System in COVID-19: An MR Imaging Study. AJNR Am J Neuroradiol. 2021; 42(12):2207-14.