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Assessment of olfactory and gustatory functions in COVID-19 patients

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Abstract

Background Olfactory and gustatory disorders are common problems encountered during the COVID-19 pandemic with a significant impact on the patient's quality of life: The aim of this study was to assess the olfactory and gustatory functions in COVID-19 patients with correlation between them and clinical and laboratory markers. This was a cross-sectional study conducted on 63 subjects recruited from the COVID-19 clinics at Police Authority and Menoufia University hospitals. The patients were assessed using history taking, anterior rhinoscopy, endoscopic examination, computed tomography, and polymerase chain reaction (PCR) test. Olfactory functions were assessed using the alcohol threshold test. Gustatory functions were assessed using the three-drop method. The olfactory and gustatory functions were correlated with age, gender, and laboratory parameters. Also, the recovery of smell and taste disorders was correlated with our assessed laboratory markers.

Results The prevalence of olfactory dysfunction among study participants was 41 patients (65%) of the participants including 12 patients (19.1%) having mild hyposmia, 10 patients (15.8%) having moderate hyposmia, 9 patients (14.3%) having severe hyposmia, and 10 patients (15.8%) having complete anosmia. The prevalence of gustatory dysfunction among study participants was 24 patients (38.1%). Age, gender, and laboratory parameters did not show any statistically significant difference between those who experienced olfactory dysfunction or gustatory dysfunction and those who did not. However, there was a significant positive correlation between the total leucocytic count, serum level of CRP, and serum level of D-dimer and the degree of olfactory dysfunction (0.049, 0.03, and 0.02, respectively). There was a nonsignificant correlation between recovery of olfactory and gustatory dysfunction and laboratory markers.

Conclusion Olfactory and gustatory dysfunction are established clinical presentations among COVID-19-positive patients. The laboratory markers had no correlation with the incidence of these dysfunctions or their recovery. However, TLC, serum CRP, and serum D-dimer had a significant positive correlation with the severity of olfactory dysfunction.

Keywords Anosmia, COVID-19, Gustatory dysfunction, Hyposmia, Olfactory dysfunction

Background

The World Health Organization provided a list of COVID-19-related symptoms including "new loss of taste or smell" [1]. Numerous reports have shown the prevalence of these symptoms in people with COVID-19 infection, which has significant impositions on diagnosis and treatment. The occurrence of smell dysfunction in viral infections is not new [2]. The most common viruses that cause olfactory dysfunction are rhinovirus, parainfluenza, Epstein-Barr virus, and certain coronaviruses.

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These viruses cause an inflammatory response of the nasal mucosa and the development of rhinorrhea [3, 4].

The underlying pathophysiological mechanism of COVID-19 anosmia is still unknown, despite an increasing amount of evidence supporting it. The olfactory cleft edema-induced conductive loss, olfactory epithelium damage, and olfactory bulb damage are among the hypothesized mechanisms [5]. In COVID-19, peripheral neurotropism and direct toxicity to taste buds are most likely the causes of transient gustatory dysfunction. Gustatory dysfunction may also result from other factors, including hypozincemia, pro-inflammatory cytokines, angiotensin II accumulation, defects in the quantity and quality of saliva, systemic diseases, and excessive chemical use [6].

The olfactory loss assessed with the alcohol threshold test has shown high sensitivity and odds ratio in both patients with confirmed COVID-19 illness and participants with suspected COVID-19 infection [7]. Different clinical tests of gustatory function have been used. The three-drop method could be used in clinical assessment of gustatory function, providing an easy and cost-effective method [8, 9]. This study aimed to assess the prevalence of olfactory and gustatory functions in COVID-19 patients with an assessment of the correlation between them and age, gender, and laboratory markers.

Methods

The current study was a cross-sectional study to assess olfactory and gustatory dysfunction in COVID-19 patients after approval of the institutional review board, and informed written consent was taken from every patient before participation in the study. The study was conducted on 63 subjects recruited from the COVID-19 clinics at Police Authority and Menoufia University hospitals during the period from January 2021 to December 2022.

The study sample size was assessed based on the study by Lechien et al. [10] who found that olfactory and/or gustatory dysfunctions were potential early clinical presentation of COVID-19 infection. Based on the odds ratio of olfactory dysfunction in SAR-CoV-2-infected patients in their study of 11.67 (95% *CI* 6.43 to 21.17), the least sample size calculated using statistics and sample size pro program version 6 was 52 subjects with a study power of 80% and confidence level of 95%. Extra 11 patients (20%) were included in the study to compensate for any dropouts from the study. The total number of patients included in the study was 63 patients according to the study inclusion and exclusion criteria.

The study included COVID-19-positive patients according to reverse-transcription polymerase chain reaction (RT-PCR) who were over 18 years of age, presenting with no or mild upper respiratory tract infection symptoms and less than 60 years old for better test compliance. Any patient with an intranasal pathology like intranasal masses or granulomas, or an uncontrolled systemic disease, was excluded from the study.

Participants were evaluated post-recovery based on World Health Organization (WHO) guidelines [11] in collaboration with the hospital COVID-19 team. Symptomatic patients were assessed 10 days after symptom onset, with at least an additional 3 days without symptoms, while asymptomatic cases were evaluated 10 days after testing positive for SARS-CoV-2.

Every patient was assessed by a detailed history to exclude other causes of smell or taste disorders, PCR to confirm the diagnosis of COVID-19, CT (computed tomography) nose, and paranasal sinuses to exclude any intranasal pathology, full laboratory workup to assess laboratory markers including (hemoglobin, total leucocytic count, lymphocytes, platelets, CRP, serum ferritin, D-dimer, ALT, AST, and serum creatinine), and to exclude patients with uncontrolled diseases.

The alcohol threshold test, validated by *Calvo-Henriquez* et al. [7], was used to assess olfactory perception. Five different concentrations of ethyl alcohol were prepared by diluting it in saline solutions: 10%, 25%, 50%, 70%, and 96%. It was made with a 100-ml solution of ethyl alcohol and regular saline. Patients were asked to identify the smell in each concentration, which was given to them in separate bottles. The bottles were held 3 cm from the patients' noses, and they were instructed to smell them in any order and try to identify which one had the lowest concentration. For the 10%, 25%, 50%, 70%, and 96% alcohol concentrations, respectively, the threshold score (TS) was 1, 2, 3, 4, and 5 to indicate the lowest amount of alcohol that the patient could detect. The patients were categorized into five categories according to alcohol threshold test (normal, mild hyposmia, moderate hyposmia, severe hyposmia, anosmia).

The three-drop method has been developed as a gustatory assessment technique that relies on aqueous solutions containing the four primary tastes—beer, sour, salty, and sweet [8, 9]. The subject was shown three samples, two of which are just water and one of which contains the taste material. The patients were asked to name the taste. Thirty seconds should elapse between each trial, during which time the mouth was cleaned with distilled water. To avoid odor inhalation, a cotton piece was used to cover the nostrils. The patients were asked to confirm the taste by matching it to a list that was provided (sweet, salt, sour, bitter, water, or no taste). Based on the results of the three-drop method test, the patients were divided into two categories: normal gustation, and gustatory dysfunction.

Patients diagnosed with olfactory or gustatory dysfunction were reassessed at 1 month after onset of dysfunction for the degree of recovery either full, partial, or no recovery.

Outcome measures

The study's primary outcome was assessing the prevalence of olfactory and gustatory functions by the ethyl alcohol threshold test for olfaction and the three-drop method tests for gustation. The study's secondary outcomes included the correlation between age, gender, and laboratory markers and olfactory and gustatory dysfunction. Another secondary outcome was the correlation between the degree of recovery at 1 month after incidence and the laboratory markers.

Statistical analysis

All statistical analyses were performed using the *SPSS* (Statistical Package for Social Science) version 25 (IBM Corp., Armonk, NY, USA). Descriptive statistics were applied in numerical form including mean and standard deviation to describe the quantitative variables and number and percentage to describe qualitative variables. Associations between variables were tested for significance by using an independent sample *t*-test to assess continuous variables with normally distributed data. Non-normally distributed data were tested using Mann–Whitney U-/Kruskal–Wallis tests for continuous variables and chi-square test for qualitative variables. Results were considered statistically significant at a *P*-value less than 0.05.

Table 1 Demographic features of the study participants

Variables	*N* (63)
Age	
Mean ± SD	41.8 ± 10.5
Gender no. (%)	
Male	40 (63.5)
Female	23 (36.5)
Hb	12.2 ± 1.5
TLC × 10^3	6.9 ± 2.3
Lymphocytes × 10^3	1.5 ± 0.6
Platelets × 10^3	302.7 ± 107.5
CRP	16 ± 14.5
Ferritin	391 ± 160
D-dimer	1 ± 1
ALT	40.5 ± 15.3
AST	40.8 ± 17
S. Creatinine	0.9 ± 0.2

Table 2 The prevalence of olfactory dysfunction among the study participants

Olfactory function		***N* (63)**
Normal		22 (35)
Abnormal	Mild	12 (19.1)
	Moderate	10 (15.8)
	Severe	9 (14.3)
	Anosmia	10 (15.8)
Gustatory function		*N* (%)
Normal		39 (61.9)
Abnormal		24 (38.1)

Results

The current study included 63 COVID-19-positive patients with a mean age of 41.8 ± 10.5 years. The study patients included 40 (63.5%) males and 23 (36.5%) females. The laboratory markers of the patients were measured showing that the mean of all variables was within normal range, except for the high levels of CRP, serum ferritin, and D-dimer (Table 1).

The prevalence of olfactory dysfunction among study participants was 65% of the participants including 12 patients (19.1%) having mild hyposmia, 10 patients (15.8%) having moderate hyposmia, 9 patients (14.3%) having severe hyposmia, and 10 patients (15.8%) having complete anosmia. The prevalence of gustatory dysfunction among study participants was 24 patients (38.1%) (Table 2).

In the present study, age, gender, and laboratory parameters did not show any statistically significant difference between those who experienced olfactory dysfunction or gustatory dysfunction and those who did not (Table 3). However, there was a significant positive correlation between the total leucocytic count, serum level of CRP, and serum level of D-dimer and the degree of olfactory dysfunction (0.049, 0.03, and 0.02, respectively) (Table 4).

In the current study, 22 patients out of 41 patients with olfactory dysfunction (537%) showed complete recovery, 11 patients (26.8%) showed partial recovery, and 8 patients (19.5%) showed no recovery. There were nonsignificant correlations between the recovery of olfactory dysfunction and laboratory markers (Table 5). Eleven patients out of 24 patients with gustatory dysfunction (45.8%) showed complete recovery, 7 patients (29.2%) showed partial recovery, and 6 patients (25%) showed no recovery. There were nonsignificant correlations between the recovery of gustatory dysfunction and laboratory markers (Table 6).

Discussion

One of the recognized symptoms of COVID-19 infection is chemosensory disorders, which include taste and smell disorders. However, clinical and demographic

Table 3 Correlation between olfactory and gustatory dysfunction and clinical and laboratory characteristics of the study participants

Parameter		Olfactory dysfunction			Gustatory dysfunction		
		Yes (41)	No (22)	*p*-value	Yes (24)	No (39)	*p*-value
Age (mean ± SD)		42.78 ± 10.85	40.09 ± 10.08	0.34	41.92 ± 10.34	41.79 ± 10.87	0.97
Gender (no)	Male	26	14	0.99	11	29	**0.02***
	Female	15	8		13	10	
Hb (mean ± SD)		12.17 ± 1.52	12.41 ± 1.43	0.54	11.79 ± 1.42	12.54 ± 1.47	0.05
TLC x 10^3 (mean ± SD)		7.261 ± 2.445	6.311 ± 2.085	0.13	7.621 ± 2.864	6.504 ± 1.893	0.07
Lymphocytes x 10^3 (mean ± SD)		1.575 ± 0.564	1598 ± 0.749	0.89	1.581 ± 0.667	1.585 ± 0.613	0.98
Platelets x 10^3 (mean ± SD)		309.71 ± 107.8	289.77 ± 108.36	0.49	297.96 ± 121.64	305.69 ± 99.46	0.78
CRP (mean ± SD)		15.88 ± 15.98	16.27 11.62	0.92	20.46 ± 19.21	.13.28 ± 9.99	0.06
Ferritin (mean ± SD)		390.27 ± 156.91	393.05 ± 170.11	0.95	402.96 ± 174.75	384.03 ± 152.6	0.65
D-dimer (mean ± SD)		0.85 ± 0.88	1.28 ± 1.3	0.12	1.09 ± 1.08	0.95 ± 1.05	0.62
ALT (mean ± SD)		40.24 ± 15.93	40.91 ± 14.6	0.87	43.33 ± 16.4	38.72 ± 14.62	0.25
AST (mean ± SD)		42.41 ± 16.9	37.86 ± 17.38	0.32	43.92 ± 17.66	38.92 ± 16.64	0.26
S. Creatinine (mean ± SD)		0.91 ± 0.22	0.88 ± 0.23	0.58	0.88 ± 0.23	0.92 ± 0.22	0.58

ALT alanine transaminase, *AST* aspartate transaminase, *CRP* C-reactive protein, *Hb* hemoglobin, *S. Creatinine* serum creatinine. *TLC* total leucocytic count. **P*-value is significant at < 0.05

Table 4 Correlation between degree of olfactory dysfunction and laboratory characteristics of the study participants

Parameter	Olfactory dysfunction				*p*-value
	Mild	Moderate	Severe	Anosmia	
Hb (mean ± SD)	12.59 ± 1.37	12.44 ± 1.73	12.34 ± 1.74	11.24 ± 1.01	0.19
TLC x 10^3 (mean ± SD)	6.658 ± 1.72	8.04 ± 1.941	5.844 ± 1.597	8.48 ± 3.479	**0.049***
Lymphocytes x 10^3 (mean ± SD)	1.561 ± 0.386	1.881 ± 0.59	1.287 ± 0.44	1.547 ± 0.728	0.12
Platelets x 10^3 (mean ± SD)	312.67 ± 91.15	351.5 ± 68.69	316 ± 97.35	258.7 ± 153.18	0.18
CRP (mean ± SD)	9.42 ± 6.43	8.6 ± 3.41	23.67 ± 25.57	23.9 ± 15.65	**0.03***
Ferritin (mean ± SD)	351.5 ± 141.05	330.4 ± 127.08	442.33 ± 220.9	449.8 ± 113.81	0.23
D-dimer (mean ± SD)	0.5 ± 0.26	0.65 ± 0.34	0.76 ± 0.54	1.56 ± 1.48	**0.02***
ALT (mean ± SD)	33.92 ± 13.93	42.6 ± 18.14	40.22 ± 13.54	45.5 ± 17.55	0.44
AST (mean ± SD)	39.42 ± 14.11	39.9 ± 16.62	42.44 ± 14.79	48.5 ± 22.25	0.86
S. Creatinine (mean ± SD)	0.97 ± 0.24	0.96 ± 0.18	0.78 ± 0.17	0.93 ± 0.25	0.18

ALT alanine transaminase, *AST* aspartate transaminase, *CRP* C-reactive protein, *Hb* hemoglobin, *S. Creatinine*, serum creatinine. *TLC* total leucocytic count. **P*-value is significant at < 0.05

data suggest that different populations and COVID-19 variants may cause different alterations in chemosensory perception. Assessment methods for taste and smell loss fall into two main categories: subjective and objective. Psychophysical testing, which measures the lowest concentration of a stimulant that can be detected measuring and quantifying human responses to physical stimuli, is an objective measure of taste and smell with a capacity to distinguish between various stimulants [12]. The current study used ethyl alcohol at varying concentrations as examples of odor threshold tests in a COVID-19 population. An additional technique to measure human olfactory performance is the Sniffin' Sticks test [13], an odor discrimination and threshold test used widely in COVID-19 patients' studies [14]. The use of taste strips (Burghart, Messtechnik, Germany) for objective taste assessment is another example of objective measures for taste assessment. These are paper strips that have been impregnated with four different taste qualities—bearing, sour, salty, and sweet—each with four different concentrations, for a total of 16 strips [15]. Objective tests could be conducted over several days to track changes in a patient's ability to taste and smell over time. However, many researchers modified these objective methods to allow patients to test at home using common household

Table 5 Correlation between the recovery of olfactory function at 2 weeks of onset dysfunction and laboratory characteristics of the study participants

Parameter	Full recovery (22)	Partial recovery (11)	No recovery (8)	Kruskal–Wallis test	*p*-value
Hb (mean ± SD)	12.48 ± 1.5	12.1 ± 1.74	11.43 ± 1.14	2.8156	0.245
TLC x 10^3 (mean ± SD)	7.164 ± 2.654	7.891 ± 2.111	6.663 ± 2.366	1.6204	0.445
Lymphocytes x 10^3 (mean ± SD)	1.594 ± 0.625	1.683 ± 0.481	1.378 ± 0.501	0.9005	0.637
Platelets x 10^3 (mean ± SD)	306.9 ± 94.6	323.1 ± 111.8	299 ± 145.9	0.3163	0.853
CRP (mean ± SD)	11.64 ± 8.068	14 ± 13.76	30.125 ± 26.45	5.2352	0.072
Ferritin (mean ± SD)	392.23 ± 148.86	396.73 ± 117.01	376 ± 233.1	1.051	0.591
D-dimer (mean ± SD)	0.71 ± 0.55	0.73 ± 0.55	1.4 ± 1.63	4.2497	0.119
ALT (mean ± SD)	37.77 ± 16.32	39.9 ± 13.23	47.5 ± 17.9	1.8424	0.398
AST (mean ± SD)	37.32 ± 16.26	46 ± 13.15	51.5 ± 19.87	4.9767	0.083
S. Creatinine (mean ± SD)	0.94 ± 0.22	0.95 ± 0.2	0.79 ± 0.24	3.6052	0.165

ALT alanine transaminase, *AST* aspartate transaminase, *CRP* C-reactive protein, *Hb* hemoglobin, *S. Creatinine* serum creatinine. *TLC* total leucocytic count

Table 6 Correlation between the recovery of gustatory function at 2 weeks of onset dysfunction and laboratory characteristics of the study participants

Parameter	Full recovery (11)	Partial recovery (7)	No recovery (6)	Kruskal–Wallis test	*p*-value
Hb (mean ± SD)	11.79 ± 1.51	12.24 ± 1.29	11.27 ± 1.44	1.916	0.384
TLC x 10^3 (mean ± SD)	7.109 ± 2.577	8.643 ± 3.423	7.367 ± 2.875	1.072	0.585
Lymphocytes x 10^3 (mean ± SD)	1.585 ± 0.730	1.859 ± 0.694	1.247 ± 0.402	2.7235	0.256
Platelets x 10^3 (mean ± SD)	332.7 ± 95.1	233.7 ± 109	309.2 ± 164.7	3.533	0.171
CRP (mean ± SD)	16.82 ± 20.76	18.14 ± 15.53	29.83 ± 20.11	1.9415	0.379
Ferritin (mean ± SD)	389 ± 228.4	396.9 ± 119.6	435.7 ± 131.2	0.9478	0.623
D-dimer (mean ± SD)	0.78 ± 0.55	0.83 ± 0.33	1.95 ± 1.85	2.4933	0.287
ALT (mean ± SD)	42.91 ± 17.17	40 ± 14.8	48 ± 18.51	0.6836	0.71
AST (mean ± SD)	38.64 ± 12.88	53.14 ± 15.89	42.83 ± 24.86	3.1624	0.206
S. Creatinine (mean ± SD)	0.88 ± 0.22	0.81 ± 0.18	0.97 ± 0.29	1.3512	0.509

ALT alanine transaminase, *AST* aspartate transaminase, *CRP* C-reactive protein, *Hb* hemoglobin, *S. Creatinine* serum creatinine. *TLC* total leucocytic count

odorants and taste materials to cope with widespread application of stay-at-home orders [16].

Subjective methods by self-report through patient questionnaires or interviews, or the extraction of symptomatic information from a patient's electronic health records, have been more frequently used techniques to quantify smell loss in the COVID-19 population [17]. However, because smell loss was not initially recognized as a symptom of COVID-19, gathering information from records may be vulnerable to underestimating the symptom. Other subjective techniques include asking patients directly about how they perceive their own sense of smell, either in person with a doctor [18] or over the phone [17] using an online questionnaire. *Jang* et al. [19] found that older age was linked to inaccurate reporting of impairment, even though the concordance rate between subjective and objective assessment of smell and taste impairment remains high. They proposed that different demographic and clinical factors influence people's subjective perceptions of smell, and that these factors should not be disregarded in clinical practice. In their systematic review, *Hannum* et al. [12] found that using objective measurements rather than subjective ones was a more sensitive way to determine whether smell loss was caused by SARS-CoV-2 infection.

In the current study, the prevalence of olfactory and gustatory dysfunction was assessed in a sample of an Egyptian population with COVID-19 infection which turned to be 65% and 38.1% respectively. These findings match the findings of other multicenter studies and systematic reviews [12, 20–22]. *Rocke* et al. [20] *analyzed* 12 papers that reported an association between COVID-19 and olfactory dysfunction. By comparing olfactory dysfunction to other symptoms in a logistic regression analysis, they found that olfactory dysfunction was the symptom that most strongly predicted

COVID-19 positivity. A total of 62% of patients with positive COVID-19 tests also had olfactory dysfunction patterns. *Chen* et al. [21] used an online questionnaire, to perform a cross-sectional study on patients with COVID-19 caused by the Omicron variant to assess the prevalence of chemosensory disorders both before and during infection. Twelve-hundred forty-five COVID-19 patients finished the survey. Smell, taste, and chemesthesis disorders were found in 69.2%, 67.7%, and 31.4% of people, respectively. They suggested that chemosensory disorders during COVID-19 may be linked to factors such as age, sex, smoking, and symptoms related to the virus, such as fatigue, dyspnea, and lack of appetite. *Hannum* et al. [22] *examined* 241 papers in a systematic review and meta-analysis. They demonstrated that 39.2% of 138,897 COVID-19-positive patients reported having taste dysfunction, and the prevalence estimates from studies utilizing direct ($n=18$) versus self-report ($n=223$) approaches were marginally but not significantly higher. They stated that males reported lower rates of taste loss than did females, and taste loss was highest among middle-aged adults. This does not match the findings of our study which showed a significantly higher incidence of taste loss in males and no effect of age on the incidence of gustatory dysfunction. This difference may be due to different sample sizes and unbalanced distribution of the current study sample between males and females.

The present study's results were around the findings of previous investigations. Thirty-four publications measuring anosmia as a COVID-19 symptom were systematically analyzed by *Hannum* et al. [12] (6 objective and 28 subjective). When measured objectively, the pooled prevalence estimate of smell loss was 77%, whereas subjective measurements yielded a value of 44%. *Tong* et al. [23] carried out a second systematic review to ascertain the combined worldwide prevalence of gustatory and olfactory dysfunction in COVID-19 patients. After analyzing 10 studies ($n=1627$) for olfactory dysfunction, they found that 52.73% of COVID-19 patients had this condition. Gustatory dysfunction was examined in nine studies ($n=1390$), showing a 43.93% prevalence and a statistically significant increase in females and younger people.

However, our results were widely above the estimated prevalence by *Saniasiaya* et al. [24] who estimated the overall pooled prevalence of olfactory dysfunction in COVID-19 patients through a systematic review and meta-analysis. In their meta-analysis, 83 studies ($n=27,492$, 61.4% female) were included. In COVID-19 patients, the overall pooled prevalence of olfactory dysfunction was 47.85%. In 35.39%, 36.15%, and 2.53% of the patients, respectively, anosmia, hyposmia, and dysosmia were noted. *Lee* et al. [18] evaluated 3191 COVID-19 patients in Daegu, Korea. A total of 15.3% (488/3191) of patients with COVID-19 in the early stages and 15.7% (367/2342) of patients with asymptomatic to mild disease severity had acute anosmia or ageusia. Their frequency was noticeably higher in younger and female individuals. This difference may be due to different sample sizes and different ethnic criteria with *Lee* et al.

Conversely, a multicenter European study led by *Lechien* et al. [10] assessed the prevalence of gustatory and olfactory dysfunctions in patients who had COVID-19 infection confirmed by a laboratory workup. Twelve European hospitals provided patients with COVID-19 infection confirmed by laboratory testing. They discovered that 88.0% and 85.6% of patients, respectively, reported gustatory and olfactory dysfunctions. Olfactory and gustatory dysfunctions affected females considerably more than males. Their reported high prevalence of gustatory and olfactory dysfunction requires further assessment and evaluation.

According to *Hafez* et al. [25], there was a correlation between the characteristics and outcomes of patients with COVID-19 who belonged to a multiethnic group recruited in the United Arab Emirates and the prevalence of olfactory/gustatory dysfunctions (OGDs). After evaluating 1785 COVID-19 patients in their cohort, they found that 11.7% of the subjects had experienced OGDs which was significantly inversely correlated with COVID-19 severity. The odds of prevalence were statistically significantly lower for males, Asians, and patients with comorbidities. Conversely, patients from Iran, the Arab world, and Emirati countries were more common. Compared to COVID-19 patients without the symptoms, those with OGDs experienced a significantly shorter time until viral clearance. They concluded that olfactory/gustatory dysfunction is common in non-severe cases of COVID-19 cases. Their reported prevalence of olfactory and gustatory dysfunction was much less than the reported prevalence by many other studies including systematic reviews. This could be explained by the multiethnic character of their cohort.

In the current study, there was a nonsignificant correlation between patients age and gender and the incidence of olfactory dysfunction. However, gustatory dysfunction was more in males with a statistical significance. There was a nonsignificant correlation between the laboratory markers and the incidence of olfactory or gustatory dysfunction. However, there was a significant correlation between the total leucocytic count, D-dimer, and CRP and the severity of olfactory dysfunction. This can be explained by the increased severity of the inflammatory process reflected by these markers.

Assessment of the study patients with olfactory and gustatory functions at 1 month after the onset of dysfunction showed that 80.5% of patients with olfactory

dysfunction and 75% patients with gustatory dysfunction reported various degrees of recovery without a significant correlation with any of the laboratory markers. These findings are around the results of *Taziki Balajelini* et al. [26] who reported that olfactory and gustatory dysfunction symptoms improved in 80.99% and 83.56% of the patients, respectively, within the first month of dysfunction onset. In the present study, 45.8% showed complete recovery after 1 month of dysfunction. This is around the results of *Lv* et al. [27] who found that 51.4% of patients showed complete recovery of olfactory dysfunction at 4 weeks after onset.

Although it has not been the scope of the current study, the treatment of post-COVID olfactory and gustatory dysfunction includes olfactory training which has the greatest degree of supporting evidence [28]. To date, several lines of treatment have been proposed including systemic and local corticosteroids to alleviate the inflammatory response in patients with postinfectious olfactory and gustatory dysfunction [28]; calcium cations chelators including intranasal sodium citrate, which modulate olfactory receptor transduction cascades [29]; intranasal vitamin A which may promote olfactory neurogenesis [30]; systemic omega-3 which may have neuro-regenerative or anti-inflammatory effects [31]; and diode laser 810 nm which help rapid recovery from loss of taste dysfunction [32].

The limitations of this study included the small sample size relative to other studies and the use of subjective methods for assessment of olfactory and gustatory dysfunction. The strength point of the study is that it has been one of the few studies evaluating this aspect in an Arabic/Middle Eastern population. Another strength point of the study is the correlation between the laboratory markers and the occurrence of olfactory and gustatory dysfunction and their recovery.

Conclusion

Olfactory and gustatory dysfunction were established clinical presentations among COVID-19 positive patients. The laboratory markers had no correlation with the prevalence of these dysfunctions or their recovery. However, TLC, serum CRP, and serum D-dimer had a significant positive correlation with the severity of olfactory dysfunction. So, otolaryngologists must pay close attention to COVID-19 option when evaluating cases of ageusia and nonspecific anosmia to avoid delayed diagnosis or misdiagnosis of COVID-19 and prevention of transmission.

Abbreviations

ALT	Alanine transaminase
AST	Aspartate transaminase
CT	Computed tomography
Hb	Hemoglobin
CRP	C-reactive protein
OGDs	Olfactory and gustatory dysfunctions
RT-PCR	Reverse transcriptase-polymerase chain reaction
S. Creatinine	Serum creatinine
TLC	Total leucocytic count

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Authors' contributions

EB provided the concept and design with the definition of the intellectual content, YK conducted clinical studies, data collection, and manuscript editing. AAH conducted clinical studies, data collection, data analysis, and manuscript editing. AMH conducted literature research, clinical studies, data collection, data analysis, and manuscript preparation. All authors have read and approved the manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Institutional Review Board of Menoufia Faculty of Medicine. The participants of the study provided written consent before participation in the study or publication of their data.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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