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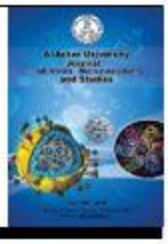

Post COVID-19 Ocular Manifestations

Heba Allah Gamal Karam[1*], Elham Abd El-Wahed Hassan[1] and Nermein El-Haddad[1]

[1] Department of Ophthalmology, Faculty of Medicine for Girls, Al-Azhar University, Cairo, Egypt.

***Email: gamalheba496@yahoo.com**

Abstract

After recovery from Corona Virus Disease 19(COVID-19) ocular manifestations can occur. The aim of the work assesses post COVID-19 ocular manifestations taking in consideration the age of patients as well as the severity of infection. The study included 150 eyes divided into: 1)100eyes of post COVID-19 patients,2)50 eyes of healthy control group. The post COVID-19 group was then divided as regard previous infection severity into mild, moderate, and severe. Patients underwent full ophthalmic examinations. visual field and macular thickness were estimated. Post COVID-19 infection patients were presented mostly with ocular pain and redness (P-value= 0.001). We reported an increasing incidence of conjunctivitis and sub-conjunctival hemorrhage in post COVID-19 infection (P-value=0.002). Punctate epithelial keratitis increased in post severe COVID-19 infection (P-value=0.004). Episcleritis & anterior uveitis were seen in post mild COVID-19 infection (2.9% P-value=0.0693 & 1.4% P-value=0.868). Cotton wool spots reported post severe COVID-19 infection (P-value=0.004). Tortuous blood vessels, branch retinal vein occlusion was reported in post mild COVID-19 infection (2.9% P-value=0.693 & 1.4% P-value=0.868). Facial nerve and third nerve palsy was discovered in post severe COVID-19 infection (6.3% P-value=0.088). No significant were found in macular & retinal nerve fiber layer thickness. Moreover, visual field parameters' mean deviation (MD) & pattern standard deviation (PSD) showed no significant changes. Post COVID-19 infection could affect the eyes in the form of increasing infection, coagulation and other ocular manifestations. So, follow-up of recovered patients is mandatory.

Keywords: COVID-19, Post COVID-19 eye & follow up.

1. Introduction

CoronaVirus Disease 2019 (COVID-19) is caused by a virus called severe acute respiratory syndrome virus (SARS-CoV-2) a part of the corona virus family. The majority of the affected patients have a full recovery. The lack of symptoms for five days or two consecutive negative PCR results can also confirm this recovery. After remission from the illness, many individuals have experienced symptoms that are different from COVID-19 symptoms. Some of these manifestations required long-term monitoring because they were chronic and persisted for a long time [1].

Patients with COVID-19 have primarily described two types of vision-related

problems: the first is caused by the infection itself and the second is caused by a vascular obstruction [2]. Numerous patients with COVID-19 have been found to have systemic vascular involvement. The virus binds to angiotensin converting enzyme 2 receptors (ACE2) presented in vascular endothelial cells, which cause endothelial degeneration and increased vascular permeability, which are early signs of organ disease. The cornea, conjunctiva, sclera, choroid, ciliary body, retina, and retinal pigment epithelium (RPE) all have high levels of ACE receptor expression in the human eye, according to an immunohistochemical investigation [3]. SARS-CoV-2-driven cytokine release syndrome (CRS), also known as hemophagocytic lymphohistiocytosis (HLH) or macrophage activation syndrome (MAS), is a potentially fatal hyper-inflammatory syndrome that is caused by a massive macrophage's activation. The immunological aspect of COVID-19 appears to be secondary to MAS syndrome [4].

The most typical anterior segment signs of post COVID-19 are conjunctivitis which can occur during COVID-19 infection or as post COVID-19 sequelae. Other signs and symptoms include lid margin hyperemia/telangiectasia, dry eye, sinusitis, orbital cellulitis, mucormycosis and orbital histiocytic lesion [5].

Posterior segment affection of post COVID-19 infection has been reported as flame-shaped haemorrhages, cotton wool and hard exudates. Paracentral acute middle maculopathy (PAMM), acute macular neuroretinopathy (AMN), combined retinal vein and artery occlusion, central retinal artery occlusion (CRAO) and central retinal vein occlusion (CRVO) have all been reported [6].

The neuro ophthalmological sequelae of COVID-19 have been reported in the form of papillophlebitis, optic neuritis, cranial nerve palsy, miller fisher syndrome (MFS), Adie's tonic pupil, neurogenic ptosis, and cerebrovascular accident with vision loss [7].

It should be emphasized that patients who require respiratory support in an ICU are more likely to experience ocular complications than other patients. The most common signs include problems of the ocular surface, elevated intraocular pressure (IOP), and sequalae's with the anterior and posterior segments [8].

Moreover, several medications used to treat COVID-19 have negative effects on the eyes, such as high doses of corticosteroids, which are linked to an increase in cataract formation, glaucoma, the onset of central serous chorioretinopathy, and mucormycosis [9].

The aim of this study assesses the post COVID-19 infection ocular manifestations taking in consideration the age of the patient as well as the severity of infection.

2. Subjects and Methods

This study was a cross- sectional, non-randomized, observational, control study. It was carried out from August 2021to March 2022 at " the outpatient clinic of Al-Zahraa University Hospital". The study was approved by the Ethics board of Al Azhar university Faculty of medicine for Girls-Cairo-Egypt and adherent to the tenets of the Declaration of Helsinki. An informed written consent was taken from each participant in this study.

2.1 The study was included

One hundred eyes of one hundred patients were examined during the first three months after recovery from COVID-19. The recovery from COVID-19 infection was proved by two negative PCR. The age of patients ranged between 20 & 80 years old. Then they were divided into mild, moderate, severe according to world health organization (WHO). Mild disease: was an infection with no clinical signs and symptoms from medical interviews and physical examinations. Moderate disease was a laboratory confirmed SARS-CoV-2 infection with the presence of pneumonia. Severe disease: was defined by laboratory confirmed SARS-CoV-2 infection with

dyspnea, blood oxygen saturation (SpO2) of 93% or less, respiratory rate greater than 30 per min, PaO2/FiO2 ratio below 300, and/or lung infiltration in more than 50% of the lung field within 24 to 48 h. Moreover, fifty eyes were taken as a control healthy group.

2.2 Exclusion criteria included

Patients younger than 20 years old, patients older than 80 years old, past history of systemic diseases affecting the eye and past history of any ocular diseases.

2.3 Study tools and procedures

All subjects in our study were subjected to full history taking included: Age, sex, the degree of COVID-19 infection, type of treatment and history of hospital admission. Routine ophthalmological examination included: patient's refraction by autorefractometer: (Nidek ARK-510 A (CO.LTD. - JAPAN), unaided and best corrected visual acuity using Landolt's chart at 6 meters, anterior segment examination by Topcon Slit-lamp, IOP measurement by Goldmann applanation tonometer and fundus examination by Indirect Ophthalmoscopy and Slit-lamp Biomicroscopy (using a + 90 D non-contact lens). Visual field was done by using Zeiss Humphrey 750i Visual Field HFA (Humphrey). Macular thickness & optic disc parameters were done by using optical coherence tomography (OCT) Optovue RTVue XR Avanti. (Optovue).

2.4 Visual field Perimetry (Humphery):

We employed the SITA standard (24-2 degree) approach. Fifty-four locations are tested while measuring 24 degrees temporally and 30 degrees nasally. Each patient's mean deviation (MD), pattern standard deviation (PSD), and pattern of visual field defect (if present) were all documented.

2.5 Macular Measurements (Optovue)

The OCT measurement was carried out using six mm long radial scans focused on the foveola. The thickness map shows the foveolar thickness (1.0 mm diameter central circle area), parafoveal (ring area between 1 mm and 3 mm in diameter) and perifoveal (ring area between 3 mm and 6 mm in diameter). Both parafoveal and perifoveal areas were divided into superior-hemi, inferior-hemi, temproral, superior, nasal & inferior quadrants.

2.6 Peripapillary RNFL Measurements (Optovue)

RNFL thickness can be obtained by using ONH scan which produces RNFL thickness map. RNFL thickness map is measured in a circle 3.45 mm which is centered on the optic disc. Data was taken from 2325 points between the anterior and posterior RNFL demarcated automatically by the device software. RNFL thickness is gives in each quadrant (superior, inferior, nasal and temporal) as well as the average total RNFL.

2.7 Statistical analysis

The statistical package for social sciences, version 23.0, was used to analyses the recorded data. Mean, standard deviation, and ranges were used to present the quantitative data. As numbers and percentages, qualitative variables were also presented. These tests were carried out: ANOVA in one direction is used to compare more than two means. For comparisons between multiple groups in non-parametric data, the Kruskall Wallis test was used. To compare proportions between qualitative parameters, the Chi-square (x2) test of significance was employed. The allowable margin of error was set at 5%, while the confidence interval was set at 95%. The p-value was therefore regarded as important as follows: P-value for probability P-values lower than 0.05 were regarded as important. P-values below 0.001 were regarded to be

highly significant. P-value greater than 0.05 was regarded insignificant.

3. Results

The current study included One hundred eyes of one hundred patients were examined during the first three months after recovery from COVID-19 in addition to fifty eyes as control. The studied sample was divided into mild, moderate and severe COVID-19 infections in percentage of (70%, 14% and 16%) respectively (Table 1).

Table (1): Prevalence severity of COVID-19 infection

	No.	%
Mild COVID-19 Inf.	70	70%
Moderate COVID-19 Inf.	14	14%
Severe COVID-19 Inf.	16	16%
Total	100	100.0%

There were highly statistically significant differences among different severities of COVID-19 infection according to isolation with a P-value=<0.001. All severe COVID-19 infection patients needed to be isolated in the hospital (100%). All of them were old age between 55-65 years' old ***(Table 2).***

Table (2): Comparison among severities of COVID-19 infection according to demographic data

Demographic data	Control (n=50)	Mild COVID-19 Inf. (n=70)	Moderate COVID-19 Inf. (n=14)	Severe COVID-19 Inf. (n=16)	Test value	p-value
Sex						
Male	18 (36%)	26 (37.1%)	10 (71.4%)	8 (50%)	x^2=6.881	0.078
Female	32 (64%)	44 (62.9%)	4 (28.6%)	8 (50%)		
Age "years"	47.28±11.63	40.66±15.79	44.57±16.08	52.75±5.28	*H*=2.381	0.237
Isolation						
Home	--	70 (100.0%) A	14 (100.0%) A	0 (0.0%) B	x^2=100.00	<0.001**
Hospital	--	0 (0.0%)	0 (0.0%)	16 (100.0%)		

Using: Chi-square test; H-Kruskal Wallis test

As regard the medication given to patients, anti - coagulants were taken 100% in severe COVID-19 infection,100% in moderate COVID-19 infection and only 2.9% in mild COVID-19 infection. Steroids were taken 100% in severe COVID-19 infection, 100% in moderate COVID-19 infection and 57.1% in mild COVID-19 infection. oxygen therapy was taken 100% in severe COVID-19 infection (Table 3).

Table (3): Comparison of the treatment given to the patients among different severities of COVID-19 infection.

Drugs	Mild COVID-19 Inf. (n=70)	Moderate COVID-19 Inf. (n=14)	Severe COVID-19 Inf. (n=16)	x2	P-value
Anti-coagulant	2 (2.9%) B	14 (100%) A	16 (100%) A	91.071	<0.001**
Steroid	40 (57.1%) B	14 (100%) A	16 (100%) A	18.367	<0.001**
Oxygen therapy	0 (0.0%) B	0 (0.0%) B	16 (100%) A	100.000	<0.001**

Using: Chi-square test; H-Kruskal Wallis test

The main duration of ocular manifestations after COVID-19 recovery was three weeks. Pain was the most common complaint after severe COVID-19 infection (37.5%, P-value = < 0.001) in patients aged between 50-55 years old. Red eye was the second complaint after moderate COVID-19 infection (28.6%, P-value = < 0.001) in patients aged above 65 years old. Diminution of vision was a frequent complaint, (12.5% and 5.7%, P-value=0.358) after severe and mild COVID-19 infections respectively. Itching was a common complaint (14.3% and 14.3%, P-value = 0.273) after both mild and moderate COVID-19 infections respectively. Headache was a frequent complaint (28.6%, 25.0% and 14.3%, P-value = 0.325) after moderate, severe and mild COVID-19 infections respectively (Table 4).

Table (4): Comparison of patient's complaint among different severities of COVID-19 infection

C/O	Mild COVID-19 Inf. (n=70)	Moderate COVID-19 Inf. (n=14)	Severe COVID-19 Inf. (n=16)	x^2	p-value
Start of the complaint duration (weeks)	4.29±5.34	2.00±1.36	3.30±2.25	1.552	0.217
Pain	0 (0.0%) B	0 (0.0%) B	6 (37.5%) A	33.511	<0.001**
Red eye	0 (0.0%) B	4 (28.6%) A	0 (0.0%) B	25.595	<0.001**
Diminution of vision	4 (5.7%)	0 (0.0%)	2 (12.5%)	2.052	0.358
Itching	10 (14.3%)	2 (14.3%)	0 (0.0%)	2.597	0.273
Headache	10 (14.3%)	4 (28.6%)	4 (25.0%)	2.245	0.325

Using: Chi-square test; H-Kruskal Wallis test

Patients with old age & post severe COVID-19 infections were subjected to ocular complications more than young patients with mild or moderate COVID-19 infections.

There was a statistically significant difference between control group and different groups of post COVID-19 infection as regards conjunctivitis with a P-value = 0.022. It represented (62.5%) after severe, (42.9%) after mild and (28.6%) after moderate COVID-19 infections. There was a statistically significant difference between control group and different groups of post COVID-19 infection as regards subconjunctival hemorrhage. It consisted of (14.3%) after moderate COVID-19 infection in patients aged 60&66 years old with a P-value = 0.002 (Fig.1a).

There was a statistically significant difference between control group and different groups of post COVID-19 infection as regards punctate epithelial keratitis with a P-value = 0.004. It was presented in (12.5%) after severe COVID-19 infection with patients aged 50&55 years old (Fig.1b).

There were two cases of episcleritis after mild COVID-19 infection (2.9%, P-value = 0.0693) in patients aged 70 years old (Fig.1c).

There was a case of unilateral anterior uveitis after mild COVID-19 infection (1.4% P- value = 0.868) in a patient aged 35 years old.

Cotton wool spots were presented in two cases after severe COVID-19 infection (12.5%, P-value = 0.004), the ages of patients were 56 and 65 years old (Fig.2).

There were two cases of tortuous blood vessels after mild COVID-19 infection (2.9%, P-value=0.693) in patients aged 35 years old.

There was one case of branch retinal vein occlusion (BRVO) after mild COVID-19

infection (1.4%, P-value = 0.868) in a patient aged 35 years old (Fig.3).
There was one case of facial nerve palsy and other case of third nerve palsy after severe COVID-19 infections (6.3% & 6.3%, P-value = 0.088) aged 70 and 50 years old respectively (Fig.4) (Table.5)

Table (5): Comparison of ocular manifestations among control group & different severity of COVID-19 infection.

Ocular manifestations	Control (n=50)	Mild COVID-19 Inf. (n=70)	Moderate COVID-19 Inf. (n=14)	Severe COVID-19 Inf. (n=16)	Test value	p-value
Incidence of complications	-	36 (51.4%)	6 (42.9%)	16 (100.0%)	*x2=14.145*	<0.001**
External appearance &Anterior segment						
conjunctivitis	0 (0%) C	30 (42.9%) B	4 (28.6%) B	10 (62.5%) A	x2=9.618	0.022*
Subconjunctival hge	0 (0%) B	0 (0.0%) B	2 (14.3%) A	0 (0.0%) B	x2=15.400	0.002*
Punctate epithelial keratitis	0 (0%) B	0 (0.0%) B	0 (0.0%) B	2 (12.5%) A	x2=13.220	0.004*
Episcleritis	0 (0%)	2 (2.9%)	0 (0.0%)	0 (0.0%)	x2=1.453	0.693
Anterior uveitis	0 (0%)	1 (1.4%)	0 (0.0%)	0 (0.0%)	x2=0.720	0.868
Posterior segment						
Cotton wool spots	0 (0%)	0 (0.0%) B	0 (0.0%) B	2 (12.5%) A	x^2=13.220	0.004*
Tortuous Blood VS	0 (0%)	2 (2.9%)	0 (0.0%)	0 (0.0%)	x^2=1.453	0.693
BRVO	0 (0%)	1 (1.4%)	0 (0.0%)	0 (0.0%)	x^2=0.720	0.868
Nerve palsy						
Facial Palsy	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (6.3%)	x^2=6.555	0.088
Third palsy	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (6.3%)	x^2=6.555	0.088

Using: Chi-square test; H-Kruskal Wallis test

As regard macular thickness either in foveal, parafoveal and perifoveal regions, there were non-statistically significant differences among control group & different groups of post COVID-19 infection (Table 6).

Table (6): Comparison of macular thickness among control group & different severity of COVID-19 infection.

Macular thickness	Control (n=50)	Mild COVID-19 Inf. (n=70)	Moderate COVID-19 Inf. (n=14)	Severe COVID-19 Inf. (n=16)	F-test	p-value
Whole image	283.10±9.33	278.90±17.42	287.50±12.52	276.25±11.29	1.867	0.139
Superior-Hemi	284.70±8.35	282.01±17.46	290.36±12.07	279.56±12.33	1.562	0.202
Inferior-Hemi	278.60±10.41	276.37±18.39	285.14±13.15	269.19±18.69	2.327	0.078
Fovea	223.70±13.98	229.29±25.94	234.71±10.67	222.06±13.82	0.706	0.448
Parafovea	314.10±5.42	315.79±16.59	324.00±9.50	311.31±18.59	1.971	0.122
Superior-Hemi	314.50±4.21	316.36±15.97	315.00±10.76	319.00±21.05	1.082	0.166
Inferior-Hemi	313.40±6.44	314.81±18.56	323.29±8.39	306.19±21.28	2.657	0.052
Tempro	305.50±5.32	308.23±17.13	316.57±11.84	301.69±21.09	2.368	0.074
Superior	319.30±4.79	319.43±15.94	318.64±11.41	321.44±22.96	1.022	0.202
Nasal	316.30±6.02	318.30±15.38	316.36±11.02	317.38±17.42	1.217	0.103
Inferior	316.50±8.26	317.33±21.02	326.14±7.82	308.25±21.70	2.349	0.076
Perifovea	281.10±9.60	272.61±15.67	277.79±14.94	276.06±11.62	2.076	0.107
Superior-Hemi	284.00±9.30	278.53±15.08	281.50±7.57	279.63±12.46	0.956	0.416
Inferior-Hemi	278.00±10.34	272.67±17.42	278.29±8.16	276.13±13.08	1.052	0.373
Tempro	270.30±8.85	261.41±20.01	269.14±9.26	268.38±14.60	2.170	0.095
Superior	282.00±9.30	278.59±12.85	280.43±5.64	278.94±10.91	0.507	0.678
Nasal	299.60±10.10	291.93±16.53	297.36±10.88	294.19±15.80	1.606	0.192
Inferior	272.50±11.40	269.69±19.48	272.50±7.20	270.00±12.59	0.227	0.877

Using: F-One Way Analysis of Variance.

As regard RNFL thickness at different quadrants, there were no statistically significant differences among control group & different groups of post COVID-19 infection (Table 7).

Table (7): Comparison of OCT optic disc among control group & different severity of COVID-19 infection**.**

Optic disc	Control (n=50)	Mild COVID-19 Inf. (n=70)	Moderate COVID-19 Inf. (n=14)	Severe COVID-19 Inf. (n=16)	F-test	p-value
C/D	0.36±0.15	0.29±0.12	0.31±0.09	0.32±0.08	1.763	0.245
RNFL						
Superior-Hemi (mm)	120.90±9.90	117.69±14.60	118.86±17.75	116.88±21.60	1.524	0.170
Inferior-Hemi (mm)	113.00±7.73	108.37±15.01	102.57±12.16	108.00±19.02	1.450	0.232
Superior quadrant (mm)	136.00±12.50	126.99±20.67	129.93±25.33	121.75±30.11	1.441	0.234
Inferior quadrant (mm)	134.40±13.59	138.99±21.94	135.57±13.82	137.63±30.80	1.084	0.166
Nasa-quadrant l (mm)	121.50±15.57	122.59±16.35	124.36±23.74	123.06±17.60	1.024	0.363
Temporal-quadrant (mm)	75.40±4.88	73.84±9.90	75.21±12.44	71.44±14.82	0.514	0.674

Using: F-One Way Analysis of Variance.

As regard the mean deviation (MD) and the pattern standard deviation (PSD), there were no statistically significant differences among control group & different groups of post COVID-19 infection. There was one case of altitudinal field defect in mild COVID-19 due to BRVO (1.4%, P-value=0.868) *(Table 8).*

Table (8): Comparison of visual field among control group & different severity of COVID infection**.**

Visual field	Control (n=50)	Mild COVID-19 Inf. (n=70)	Moderate COVID-19 Inf. (n=14)	Severe COVID-19 Inf. (n=16)	Test value	p-value
MD "dB"	-3.06±0.65	-5.36±16.40	-3.50±3.66	-4.91±3.96	F:0.215	0.886
PSD "dB"	2.52±0.97	2.87±2.23	2.68±1.70	3.39±1.85	F:0.626	0.600
Defect						
altitudinal defect	0 (0.0%)	1 (1.4%)	0 (0.0%)	0 (0.0%)	x^2:0.720	0.868

Using: F-One Way Analysis of Variance.

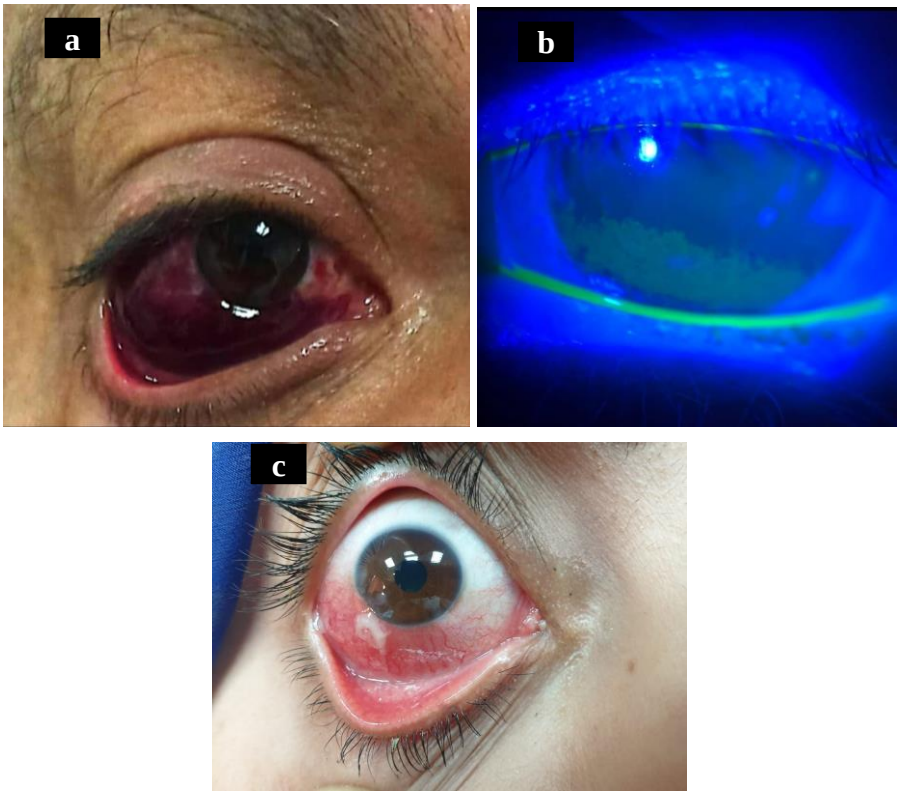

Figure (1): Anterior segment manifestations post COVID-19 infections, (a) A case of sub-conjunctival hemorrhage after moderate COVID-19 infection in patient aged 60 years old. (b) A case of punctate epithelial keratitis staining with fluorescence after severe COVID-19 infection in patient aged 55 years old. (c) A case of sectoral redness due to episcleritis after mild COVID-19 infection in patient aged 70 years old.

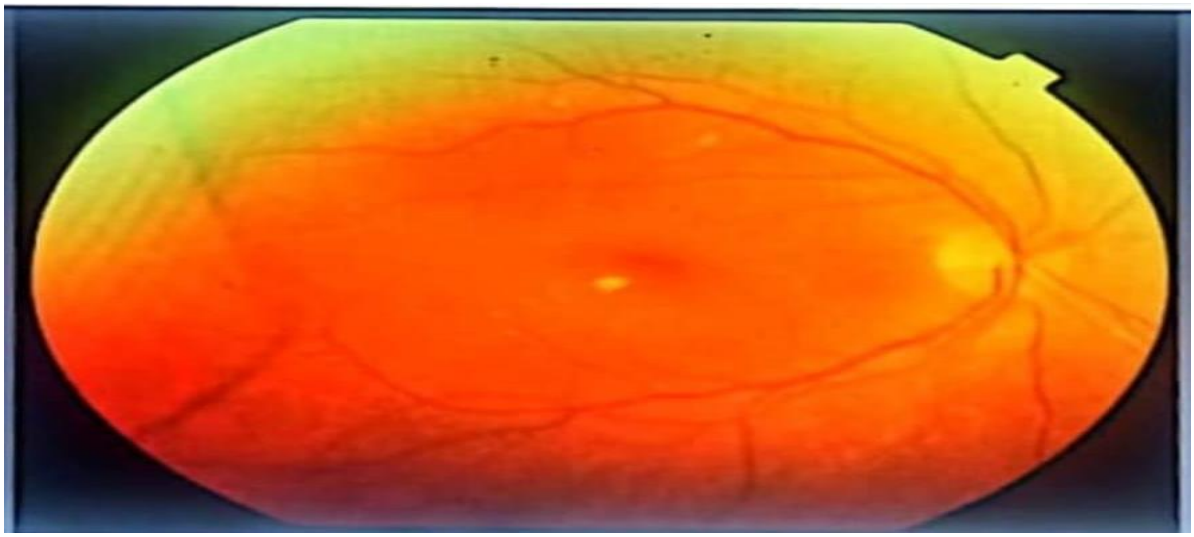

Figure (2)*:* Fundus photography showing a case with cotton wool spot after severe COVID-19 infection in patient aged 55 years' old.

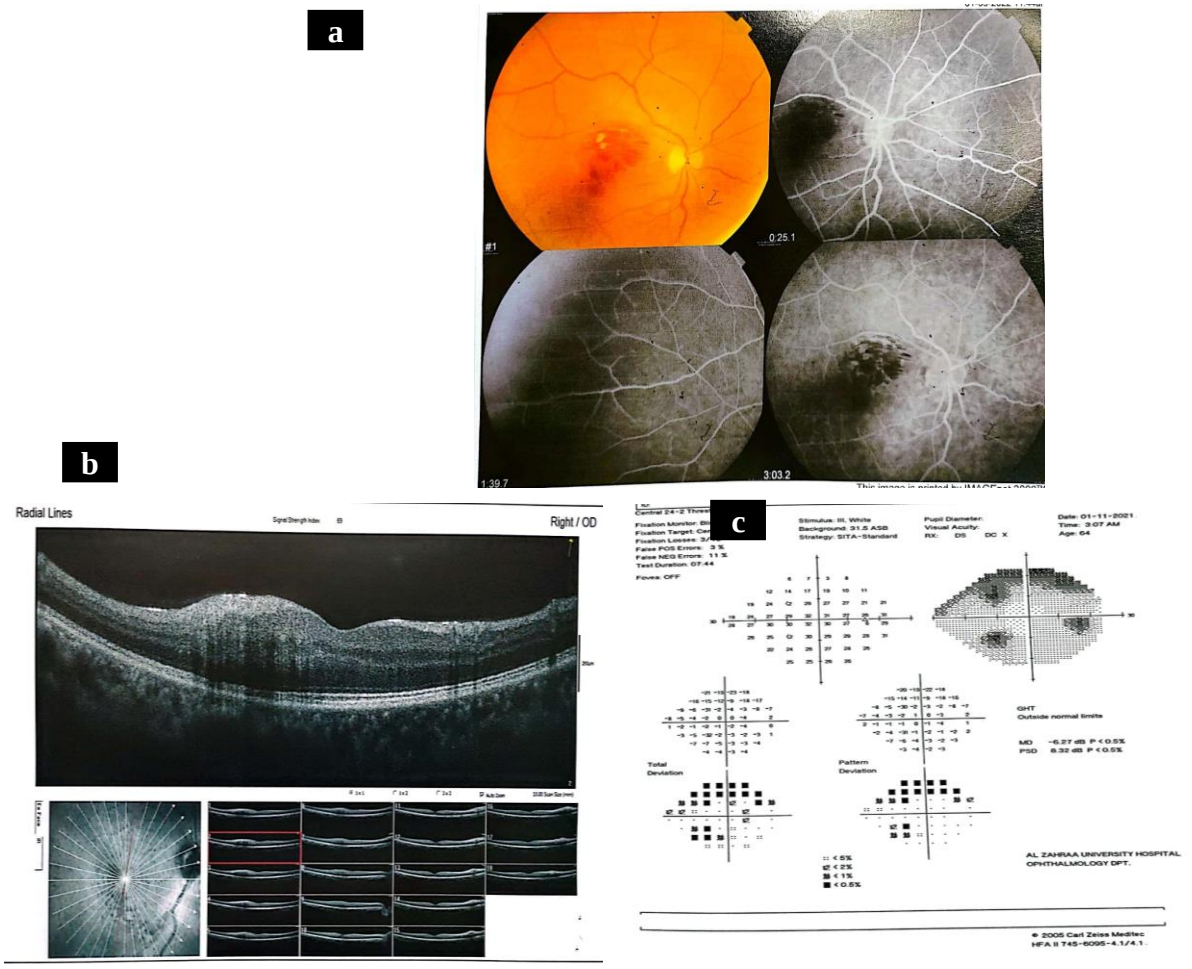

Figure (3): BRVO after mild COVID-19 infection in patient aged 35 years old. (a) Fundus fluorescence angiography showing the area of blockage with leakage increased in intensity corresponding BRVO. (b) OCT macula showing macular edema. (c) Visual field showing altitudinal defect corresponding to BRVO.

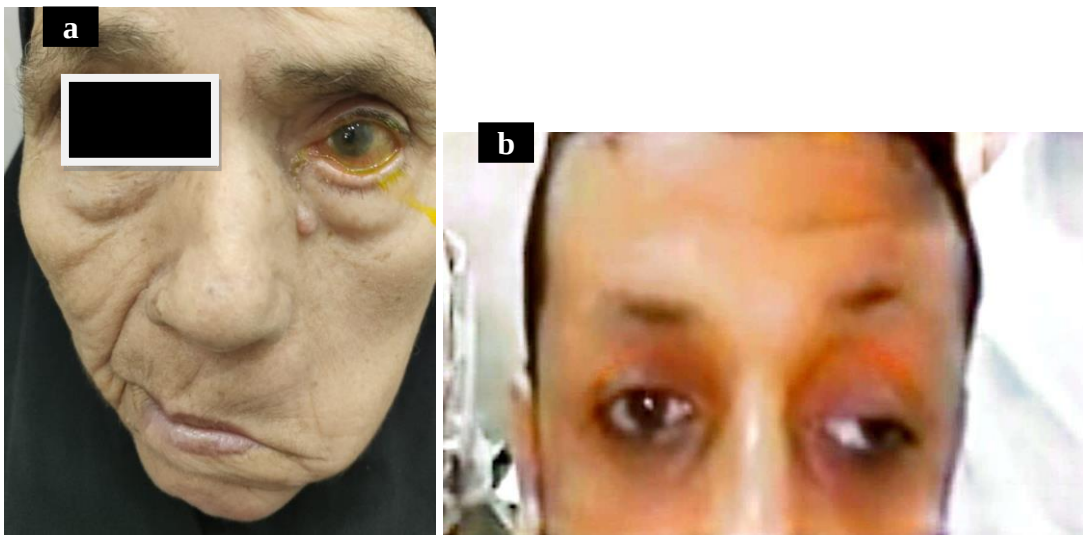

Figure (4): Nerve affection of post COVID-19 infections, (a) A case of lower facial palsy after severe COVID-19 infection aged 70 years old. (b) A case of third nerve palsy after severe COVID-19 infection aged 50 years old.

4. Discussion

The COVID-19 outbreak has been a major global concern since December 2019. The World Health Organization declared a pandemic on March 11, 2020. This catastrophe has had a severe effect on all nations, overwhelming all health care systems [10].

The effects of COVID-19 on the eyes have not been thoroughly investigated. Numerous recent studies have revealed the presence of nonspecific retinal symptoms like microhemorrhages, vein dilatation, cotton-wool patches, and haemorrhages in the form of flames. However, given the wide prevalence of comorbidities in the general community, it has not been possible to definitively determine whether these symptoms were related to COVID-19 infection or were completely accidental outcomes due to the high frequency of comorbidities in the general community [11].

The COVID-19 virus is an RNA virus that belongs to the coronaviridiae family. As evidenced by binding with ACE2 receptors (RPE), an immunohistochemical investigation of human eyes revealed the cornea, sclera, choroid, ciliary body, retinal pigment epithelium and retina as the primary sites of contact between SARS-CoV-2 and host. The cytokine storm that the SARS virus produces damages the integrity of the vascular endothelium and results in ocular disorders by causing increased permeability, activated coagulation, and microcirculation abnormalities [12].

We reported that main post COVID-19 infection patient's complaint was pain, red eye, diminution of vision and itching in percentage of (37.5%,28.6%,18.2% and 14.3%) respectively. While *McHarg et al.* [13] reported that most common post COVID-19 patient's complaint were itching, red eye, pain and blurred vision in percentage of (24.9%, 24.5%,24.5% and 22.7%) respectively.

In our study pain was the most common complaint after COVID-19 infection (37.5% of post severe COVID-19). This matches with *Desai et al.* [14] who reported pain as the most presenting complaint in post COVID-19 patients. Pain may be due to inflammation as in episcleritis. However, it may be due to infection as in mucormycotic.

Red eye was the second common complaint after COVID-19 infection. It affected 28.5% of post moderate COVID-19. *Shakhzodbek et al.* [15] reported a case with red eye in post COVID-19 patient. Red eye was a result of subconjunctival hemorrhage occurring in patients who received anticoagulants. Moreover, red eye occurred as a result of infectious conjunctivitis happened due to decreasing the immunity after COVID-19 infection. Moreover, itching was a frequent complaint after COVID-19 infection. It affected 14.3% of post moderate and mild COVID-19. *Wan et al.* [16] described itching sensation as the most frequent symptom in post COVID-19 patients. Itching was due to allergy resulting from immunomodulation after COVID-19 infection.

Diminution of vision was a common complaint after COVID-19 infection. It affected 12.5% and 5.7% of post severe and mild COVID-19 respectively. *Putilina et al.* [17] described diminution of vision as the most common complaint in post COVID-19 patients. The diminution of vision in our study was due to uveitis and retinal complications.

Headache was a frequent complaint after COVID-19 infection. It affected 28.6%,25% and 14.3% of post moderate, severe and mild COVID-19 respectively. *Fernández-de-Las-Peñas et al.* [18] reported headache as most common presentation in post COVID-19 patients. Headache could be due to neurological affection after COVID-19 infection. Conjunctivitis was the most common sign in post COVID-19 patients. It affected

(62.5%,42.9% and 28.6%) post severe, mild and moderate COVID-19 infections respectively. *Amato et al.* [19] reported a case with recurrent conjunctivitis in a post COVID-19 patient. Conjunctivitis was due to altered immunity after COVID-19 infection and using steroids in the treatment regimen which could decrease immunity.

However, Pellegrini et al. [20] has also reported decreasing in the number of cases of conjunctivitis. The limitation of infectious conjunctivitis spread was as a result of measures taken to control COVID-19.

Episcleritis affected (2.9%) of post mild COVID-19 infection. *Chaudry et al.* [21] reported a case of episcleritis in a post COVID-19 patient. Episcleritis may be due to infection or immunomodulation occurred after COVID-19 infection. Subconjunctival hemorrhage affected (14.3%) of post moderate COVID-19 infection. *Hafzah et al.* [22] reported a case with sub conjunctival hemorrhage in post COVID-19 patients. Subconjunctival hemorrhage was due to an anticoagulant given as part of the treatment of COVID-19 infection.

Anterior uveitis affected (1.4%) of post mild COVID-19 infection. *Bettach et al* [23] reported a case with bilateral anterior uveitis in a post COVID-19 patient. Anterior uveitis could be explained on an immunological basis.

Punctate epithelial keratitis affected (12.5%) of post severe COVID-19 infection. *Yener* [24] reported cases with punctate epithelial keratitis in post COVID-19 patients. Punctate epithelial keratitis was due to the absence of blinking and loosening of the orbicularis oculi muscle, which occurs due to either the use of muscle relaxants and sedative agents in patients under mechanical ventilation or as a result of facial nerve palsy, may lead to drying of the ocular surface and punctate epithelial keratitis. The usage of continuous positive airway pressure (CPAP) and oxygen masks in patients with COVID-19 may cause the ocular surface to dry and lead to infection development.

Cotton wool spots affected (12.5%) of post severe COVID-19 infection. *Shah et al.* [25] *reported* cotton wool spots in post COVID-19 patients. Cotton wool spots could be explained by the ischemic insult of COVID-19 infection. That occurred despite receiving anticoagulant medications.

Tortuous retinal blood vessels affected (2.9%) of post mild COVID-19 infection. *Jampol et al.* [26] reported cases of tortuous blood vessels as intraocular consequences in post COVID-19 patients. Tortuous retinal blood vessels may be due to the associated hypoxia with post COVID-19 syndrome. BRVO affected (1.4%) of post mild COVID-19 infection. *Yahalomi et al.* [27] reported a case developed retinal vein occlusion in post COVID-19 patient. RVO was due to thrombotic effect of COVID-19. The predilection for mild in this study was due to the lack of anticoagulants in their treatment.

Facial palsy affected (6.3%) of post severe COVID-19 patient. *Kerstens et al.* [28] reported a case with bilateral lower facial palsy after recovery from COVID-19 infection.

Third palsy affected (6.3%) of post severe COVID-19 patient. *Douedi et al.* [29] reported a case of third nerve palsy after recovery from COVID-19 infection. Nerve palsy in post COVID-19 patients could be explained by either direct viral neurological injury or as an inflammatory response. As regard macular thickness this study showed non-significant differences among control group & different severity of COVID-19 infection.

Yildiz et al. [30] *and Oren et al.* [31] reported increased macular thickness than controls in the post COVID-19 group. These studies may be influenced by the existence of comorbidities such as diabetes and hypertension in their patients. Regarding RNFL, this study showed non-

significant differences among control group & different severity of COVID-19 infection. Our study supports *Szkodny et al.* [32] who did not find any differences between the study and control groups in RNFL thickness.

However, *González-Zamora et al.* [33] *and Burgos-Blasco et al.* [34] reported a significantly thicker RNFL observed in post COVID-19 cases compared to controls due to inflammatory response.

In country to this study, *Oren et al.* [31] reported that RNFL thickness measurements in all sections was thinner in the post COVID-19 group than controls, this may be due to diabetes, hypertension and other systemic risk factors not excluded from the study. Moreover, their examination was done 14–30 days after the onset of symptoms. The discrepancy among the studies can be explained by that viral inflammation and infiltration in the early stage causes thickening, which eventually subside with progressive loss of the RNFL, resulting in thinning. Regarding visual field, it showed non statistically significant differences among control group & different severity of COVID-19 infection. However, we found single case in this study with an altitudinal field defect in branch retinal vein occlusion (BRVO).

Also, *Tsiropoulos et al.* [35] reported cases with altitudinal visual field defects diagnosed as retinal vein occlusions (RVO) in post COVID-19 patients.

To our knowledge, this is the first study that screened post COVID-19 patients after recovery to detect the ophthalmological effects of COVID-19 recovery. It is the first study that gives a percentage of each complication according to the degree of COVID-19 infection.

The limitation of this study was the small sample size. So, other studies of larger populations number should be performed. Another limitation of this study was studying adults only. Other studies including children should be done. Also, we studied COVID-19 infection without stain specification. Other studies with stain specification should be done to know which COVID-19 strain has more ocular side effects after recovery.

5. Conclusion

COVID-19 infection global pandemic has had far-reaching and long-lasting sequelaes. The full spectrum of the disease has not been revealed yet. The permanent consequence to the eye, the various presentations and theories of pathogenesis are being reported. COVID-19 could cause various eye manifestations after recovery. Recovery from the main disease does not guarantee eye safety, particularly in high-risk patients. That is why follow up of cases is mandatory.

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Conflicts Of Interest

There are no conflicts of interest.

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