ORIGINAL ARTICLE

Comparison of Visual Field in Healthy Eyes with Surgical Mask Usage in Different Ways

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Background: The coronavirus disease pandemic has affected the way of life and health system. The use of face masks can reduce the spread of the virus, however, improper fitted masks reported results in inferior visual field artifacts. The effect of wearing a properly fitted face mask remains unclear.

Objective: To compare the sensitivity in 21 points mostly in the inferior field of visual field in healthy eyes under two conditions of ear-loop surgical face mask use.

Materials and Methods: Thirty-six participants, with 36 healthy eyes, underwent computerized visual field testing using the program SITA Standard 24-2. The participants were instructed to wear masks at the lowest position that covered the nose with sealed tape along the entire length of the superior border for the first two tests and unsealed tape for the third test. The sensitivity of the visual field was analyzed and compared between the two groups. Furthermore, factors that may affect the sensitivity of the visual field were investigated.

Results: The present study showed statistically significant differences in the two test points of the sensitivity of the visual field, namely, the inferonasal and superonasal areas of the visual field between the two groups. Fogging and displacement of the mask were observed when the mask was worn without adhesive tape.

Conclusion: Wearing a surgical face mask with the mask placed in a low position and covering the nose with adhesive tape, can reduce fogging and prevent the displacement of the mask. This may reduce the incidence of mask-related artifacts and eliminate the pseudo-progression of visual field assessment.

Keywords: Surgical mask; Visual field; COVID-19

Received 12 September 2023 | Revised 23 May 2024 | Accepted 23 May 2024

J Med Assoc Thai 2024;107(7):543-9

Website: http://www.jmatonline.com

The coronavirus disease 2019 (COVID-19) pandemic has had a significant impact on public health and day-to-day life globally. The respiratory system is the primary route of the spread of the severe acute respiratory syndrome coronavirus(1,2). The practice of maintaining a distance of at least one meter and wearing a mask are method of preventing the spread of the virus(3). The visual fields of patients with glaucoma must be evaluated at least once a year to assess the progression of the condition and adjust the dosage of the anti-glaucoma medications. However, the patients had to undergo testing in poorly ventilated rooms during the COVID-19 pandemic, especially during the measurement of the visual field. A few case reports(4,5) and studies have shown that wearing a face mask that did not fit properly to the faces of the patients with glaucoma(6-8) and those with normal eyes(9,10) affected the visual field assessment. Multiple types of face masks, such as surgical face masks, KN95, and FFP2, were worn by the patients while undergoing the visual field test in the study on patients with glaucoma(6). Another case series reported that significant obstructions in inferior altitudinal visual fields were associated with duckbill N95 masks and not three-ply surgical masks(10). The visual fields of the test subjects in the study worsened and became less reliable despite the stability of the disease, particularly in a lower visual field, due to the mask getting displaced to an incorrect position or the exhaled air fogging the test lens or the glasses of the patient during the test. Consequently, the method of wearing a surgical mask was modified such that the mask was placed at the lowest position covering the

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How to cite this article:

Boonyaleephan S, Srisat P. Comparison of Visual Field in Healthy Eyes with Surgical Mask Usage in Different Ways. J Med Assoc Thai 2024;107: 543-9.

DOI: 10.35755/jmedassocthai.2024.7.14011

nose and the entire length of the superior border was covered with adhesive tape[6]. Most visual fields were reliable and returned to the baseline of the patients when not wearing a surgical mask. In a study on healthy eyes[9], an ear-loop surgical face mask was worn in three different positions with and without a nose clip during the visual field test. The sensitivity of some test points in the inferior nasal field differed significantly from the reference when the mask was worn 1.5 cm below the lower eyelid without using the nose clip. However, wearing the mask 1.5 cm below the lower eyelid with a nose clip[9] also resulted in a lower nasal visual field defect. Therefore, the present study aimed to compare the sensitivity of the visual field in healthy eyes under two conditions related to an ear-loop surgical mask use, 1) placing the surgical mask above the nose using the nose clip and 2) at the lowest position covering the nose with an adhesive tape covering the entire length of the superior border.

Materials and Methods

The present study was an experimental study approved by the Institutional Review Board of the Srinakharinwirot University (SWUEC-487/2565F) and registered in the Thai Clinical Trials Registry (TCTR20230802001) and was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants. The present study was conducted between June 2022 and October 2022 at HRH Princess Maha Chakri Sirindhorn Medical Center, Srinakharinwirot University.

The inclusion criteria were age 18 to 60 years, a best-corrected visual acuity (BCVA) of at least 20/30 (Snellen notation), spherical equivalent refraction not more than ±6 diopters, intraocular pressure (IOP) within the normal range at 21 mmHg, normal slit-lamp examination results, no abnormalities of the optic disc or signs of glaucoma in fundus photography with a C:D ratio greater than 0.5, focal or diffuse loss of neuroretinal rim or notching or retinal nerve fiber layer defects, disc hemorrhage compatible with glaucoma, no history or family history of glaucoma, no history of undergoing intraocular or laser surgery in the best eye, and no history of receiving medications such as hydroxychloroquine[11], chloroquine, antituberculosis medications such as ethambutol[12], deferoxamine[13], or tamoxifen[14] continuously, which may result in damage to the macula or optic nerve.

The exclusion criteria were abnormalities of the macula, optic disc, and retinal nerve fiber layer detected on optical coherence tomography (OCT), inability to complete all three consecutive visual field tests, and fixation loss (FL) greater than 25%, false positive greater than 15%, or false negative greater than 15%[15] in the second and third visual field test.

The sample size was calculated and evaluated to compare the two dependent means. The following was displayed for a given value. The mean outcome and standard deviation in groups 1 and 2 were referred to from Weber et al.'s (2021) outcome[9].

Beta error (Type II)=0.20
Mean outcome in Group 1=26.6[9]
Mean outcome in Group 2=28.3[9]
Difference data between two groups=1.7
Standard deviation in Group 1=2.4[9]
Standard deviation in Group 2=2.4[9]
Standard deviation=2.4
Estimated required sample sizes=16 per group

All participants underwent a complete ophthalmological examination, including slit-lamp microscopy, non-contact tonometry, and fundoscopy. All participants underwent three visual field tests using the SITA standard 24-2 computerized visual field testing (Humphrey Visual Field Analyzer 3, model 860, Zeiss Company, Germany) software.

Forty eyes of 40 participants were enrolled. Since none of them had previously undergone a visual field test, the exclusion criteria on reliability were to be considered after the second and third tests.

The first visual field test was performed to familiarize the participants with the procedure. The participants were wearing an ear-loop surgical face mask at the lowest position, covering the nose with adhesive tape covering the entire length of the superior border, as shown in Figure 1[6]. If fogging of the trial lenses or glasses was observed after taping, the mask was re-taped, and the test was repeated until fogging was no longer observed.

When the participants had already learned to do the visual field test, the participant was given a break of approximately five minutes to reduce eye fatigue and the second visual field test was started with the same mask used in the first test. They were instructed to observe any fogging on their glasses or test lenses, as well as mask displacement.

After another 5-minute break, a new surgical face mask was worn above the nose without adhesive tape in the last test. This mask was worn such that the upper edge of the mask was approximately 1 cm below the lower eyelid. The position was marked, and the nose clip was used to attach the mask firmly to the face by the technician, as shown in Figure 2. The

Figure 1. A participant wearing an ear-loop surgical face mask at the lowest position covering the nose with adhesive tape covering the entire length of the superior border.

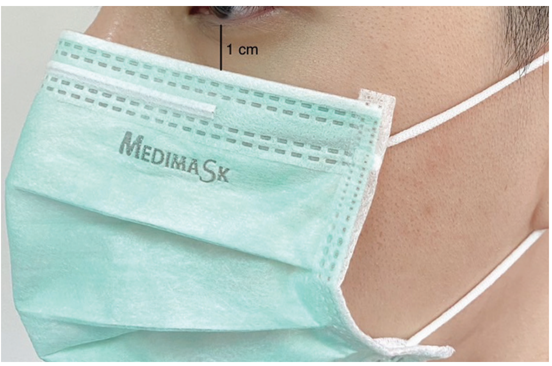

Figure 2. A participant wearing an ear-loop surgical face mask covering the nose and mouth with the upper edge of the mask approximately 1 cm below the lower eyelid. A nose clip is used to fix the mask close to the face.

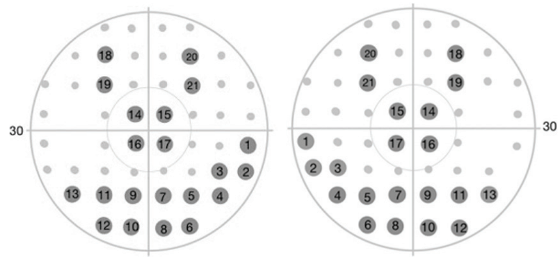

Figure 3. Sensitivity points of the visual field for all 21 locations.

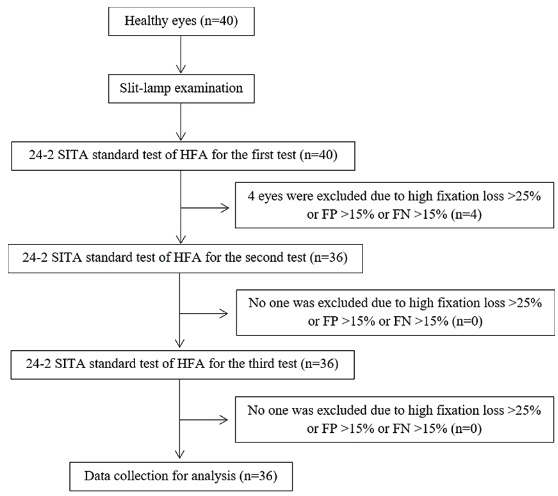

Figure 4. Flowchart for the study.

participants were allowed to exhale subsequently and were informed to report any fogging on their glasses or test lenses and not to move the mask. Furthermore, the technician rechecked the patients for any fogging or mask displacements when the participants reported them during the entire procedure.

FL, false positives, and false negatives were the three key data points gathered to determine the validity of the visual field test. The exclusion criteria for the present study were high FL greater than 25%, false positives greater than 15%, and false negatives greater than 15% on the second and third tests(15). Data were gathered by a medical student as sensitivity points of the visual field for each of the 21 locations as shown in Figure 3 and expressed in decibels, to reduce information bias.

The dependent t-test was used to compare all 21 visual field sensitivity points between the second and third tests when the data were normally distributed. The Wilcoxon signed-rank test was used when the data had different distributions. Statistical significance was set at p-value less than 0.05. In addition, variables, such as fogging on glasses, trial lenses, or mask displacement, as shown in previous studies(4-6) were documented as they may alter the visual field when wearing an ear-loop surgical face mask. Statistical analysis was done by IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY, USA).

Results

Forty eyes of 40 participants were enrolled. Four participants were excluded based on the exclusion criterion (high FL). Thus, 36 eyes of 36 patients, with seven men, or 19.5%, and 29 women, or 80.5%, were included in the present study as reported in Figure 4. The mean age of the participants was 40.1 years with a range of 23 to 60 years. The demographic data of the participants are summarized in Table 1. There were no reports of adverse events. Twenty-eight eyes (77.7%) had a BCVA of 20/20, whereas eight eyes (22.3%) had a BCVA of 20/30. The mean IOP was 13.7±2.57 mmHg, with a range of 8 to 19 mmHg.

Table 1. Demographic data (n=36)

Variable	
Sex; n (%)	
Female	29 (80.5)
Male	7 (19.5)
Age (years); mean±SD (range)	40.1±11.5 (23 to 60)
BCVA (Snellen notation); n (%)	
20/20	28 (77.7)
20/30	8 (22.3)
IOP (mmHg); mean±SD (range)	13.7±2.57 (8 to 19)

SD=standard deviation; BCVA=best-corrected visual acuity; IOP=intraocular pressure

The dependent t-test was used to compare a normal distribution of the visual field sensitivity points between the second and third tests. Test points with different distributions were analyzed with the Wilcoxon signed-rank test. The mean sensitivity, standard deviation, mean difference, standard difference, and p-value of the visual field of the 21 test points in the second and third tests of the 36 participants are shown in Table 2. There were only two test points, test points 2 and 20, where statistically significant differences were observed between the two groups as reported in Figure 5. The mean difference in visual field sensitivity was decreased by 1.11 and 1.08 decibels at test points 2 and 20, respectively. The mean difference of the 21 test points is reported in Figure 6.

As reported in a previous study on the use of an ear-loop surgical face mask in healthy eyes(9), fogging and mask displacement may affect the visual field when wearing a mask(4-6,9). In the present study, there was no mask displacement or fogging of the glasses or trial lens in the second test, wherein the mask was sealed with adhesive tape. For the third test, wherein the mask was not sealed with adhesive tape, fogging was observed in eight participants (22.2%), and downward displacement of the surgical mask was observed in eight participants (22.2%). There was no upward movement of the mask observed in any of the participants. Fogging and downward displacement of the mask were observed in one participant.

Table 2. The mean sensitivity, standard deviation, mean difference, standard difference, and p-value of the visual field of the 21 test points in the second and third tests (n=36)

Test point	MS2	Std2	MS3	Std3	Mean difference	Standard difference	p-value
1	29.86	2.45	30.03	2.47	–0.17	1.95	0.611
2	29.17	2.46	30.28	2.68	–1.11	2.50	0.012*
3	30.81	2.20	30.72	1.98	0.08	2.16	0.818
4	30.75	2.30	30.19	2.93	0.56	2.30	0.156
5	30.69	1.58	30.42	1.92	0.28	1.39	0.237
6	29.56	2.80	29.86	2.28	–0.31	2.40	0.450
7	30.28	2.02	30.58	1.52	–0.31	1.65	0.275
8	28.97	2.41	29.69	2.34	–0.72	2.25	0.062
9	30.03	1.93	30.39	2.07	–0.36	2.04	0.297
10	29.00	3.22	28.86	2.24	0.14	2.93	0.778
11	30.44	2.02	30.64	1.53	–0.19	1.89	0.493
12	28.11	2.71	28.86	2.52	–0.75	2.32	0.065
13	29.61	3.04	29.89	2.45	–0.28	1.92	0.392
14	32.14	1.51	32.22	1.42	–0.08	1.46	0.814
15	32.31	1.62	32.17	1.50	0.14	1.46	0.533
16	32.33	1.74	32.61	1.61	–0.28	1.78	0.346
17	32.53	1.63	32.44	1.84	0.08	1.83	0.786
18	28.72	2.24	29.17	2.43	–0.44	2.71	0.332
19	30.58	1.63	30.92	1.73	–0.33	1.33	0.142
20	27.89	3.16	28.97	2.13	–1.08	2.31	0.008*
21	30.14	1.88	29.86	2.61	0.28	2.39	0.941

Test 2: The surgical face mask is placed at the lowest position covering the nose with adhesive tape covering the entire length of the superior border (second test), Test 3: The surgical face mask is placed just over the nose and mouth (third test), MS2: mean sensitivity of the second test, Std2: standard deviation of the second test, MS3: mean sensitivity of the third test, Std3: standard deviation of the third test

* Statistical significance, p<0.05

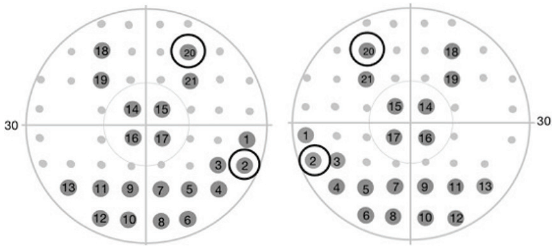

Figure 5. The 2 test points where statistically significant differences were observed.

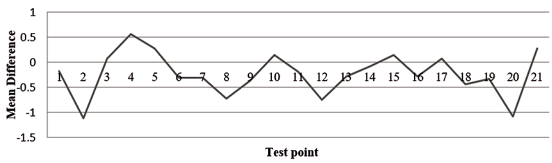

Figure 6. The mean difference of the 21 test points.

Discussion

Although the severity of the COVID-19 pandemic has lessened, the pandemic is not yet over. Patients, especially the elderly, should continue wearing face masks as most glaucoma patients are older and vulnerable to infections. Visual field assessment is an essential tool to detect the progression of glaucoma. However, these tests are subjective investigations and can be unreliable due to causes, such as age(16,17), patient condition, fatigue due to prolonged testing, ptosis, pupil size, and trial lens rim occlusion(18). Moreover, the type and position of face masks may affect the visual field, especially bulky contour masks(10) that fit poorly, which may result in the displacement of the mask toward the lower eyelid and fogging of the lens. One study has reported ocular irritation and dryness among mask users(19). Dryness of the eyes owing to a poorly fitting mask may affect the visual acuity-related sensitivity of the visual field during assessment, particularly in patients with glaucoma.

Case reports and studies have analyzed the relationship between face mask use and visual field artifacts, especially inferior defects(4-10). To the best of the authors knowledge, there are only two studies that reported that face masks affected the visual field test in normal eyes(9,10). One study(9) reported a statistically significant difference in sensitivity at some test points of the OCTOPUS 900 (V3.6.1) in healthy eyes with the use of tape-sealed surgical face masks. Another case series(10) published that Duckbill N95 masks were linked to significant blockages in inferior visual fields in healthy eyes but did not affect visual fields in surgical masks without sealed tape. Due to the conflicting information, the present study aimed to compare the visual field measured by the Humprey Visual Field Analyzer 3 in healthy eyes with surgical mask used with or without adhesive tape.

One study(9) reported that visual field function was significantly impaired at 10 of 14 test points while wearing a mask 1.5 cm below the lower eyelid without using the nose clip. Additionally, the positions of the surgical masks, which are closer to the lower eyelid, affect the inferior visual field, even if nose clips were used(9). Accordingly, the present study ensured that the masks were worn in the lowest position and that the entire length of the superior border was covered in adhesive tape. In the present study, the authors chose only surgical masks due to their availability and inexpensive as compared to KN95 or FFP2 masks. Moreover, the surgical face masks are more flexible and adapt better in the edges to any facial morphology, while most KN95 and FFP2 designs presented a rigid edge on the nose bridge that does not seal well, causing fogging.

The present study data showed statistically significant differences at test point 2, which was located in the inferonasal area of the visual field, and test point 20, which was located in the superonasal area, between the two groups. The same results were described in case reports(4) and studies(6,9), which showed that the inferior field was the most affected area when using the face mask. In addition, the present study found no fogging of the trial lens or spectacles in the second test, which involved sealing the mask with adhesive tape, like in other studies(5,7). Fogging can produce artifacts that resemble glaucomatous visual field defects and lower the reliability of visual field tests(5). Nevertheless, there were no consistent forms or locations for artifacts associated with face masks(7). Wearing a surgical face mask in the lowest position and covering the nose with adhesive tape the entire length of the superior border makes the results of the visual field tests more reliable and reduces the requirement for repeating the visual field if artifacts of the visual field were suspected, thereby saving the patient's time and preventing the overdiagnosis of glaucoma progression if the mask was worn during every visit. Moreover, the workload of the technician or personnel involved in the visual field assessment can be reduced by setting practical guidelines on how to wear a surgical mask for all patients before performing the visual field assessment. This would be particularly useful in the case of patients with glaucoma who may have a narrow visual field baseline and other patients undergoing visual field examinations.

It is to be noted that poor experience in visual field test taking may induce similar artifacts to fog, in addition to worse test reliability. Differentiating between the effects of learning and face mask taping to reduce fogging in new participants who have no prior experience undergoing visual field tests may be challenging. Therefore, in the present study, only the reliable visual fields in the second and third tests were enrolled due to reduced learning effects. An additional cause of artifacts might be upward displacement of the mask, which would result in inferior scotomas like the defect in the superior field caused by the eyelid. However, the authors did not find any upward displacement of the mask.

The present study has limitations. First, the study did not compare the groups wearing masks with a control group that did not wear masks owing to ethical concerns regarding the spread of the COVID-19 infection. Second, the measurement sequence was not randomly assigned, so the data could be biased. Third, the study only compared one type of face mask, the ear-loop surgical face mask, and did not include other types of masks, as reported in a previous study[6,10]. Fourth, the present study enrolled only healthy participants. Testing mask-induced visual field impairment would be of interest in patients with glaucoma and visual field loss. The variability of visual fields increases with reduced sensitivity[20,21]. Thus, the small visual field effect of tape-sealed face masks in the present study may have a greater effect on patients with advanced glaucoma. Fifth, the study assessed only three visual field tests in one visit. Thus, the result has limited in its application on the long-term effects of wearing a face mask in the visual field. Lastly, any fogging was rechecked when participants reported. The accuracy of face mask wearing impact on visual field test results may be compromised by bias in self-reported data. However, this may be more problematic if technicians need to observe fogging all the time of the test due to social distancing.

In the future, the study may be modified to evaluate the visual field in both healthy and glaucomatous eyes by performing comparisons with the groups without face masks and with other types of face masks, such as N95, KN95, or FFP2.

Conclusion

The present study showed that wearing a surgical mask at the lowest position covering the nose with the entire length of the superior border covered by adhesive tape is a hassle-free technique, causes no fogging, and prevents displacement of the mask during the visual field assessment, which may interfere with the interpretation of the visual field. The mask being attached firmly to the faces of the participants by the technician may also have been helpful.

What is already known on this topic?

The effects of wearing face masks that do not properly fit to the face affected the visual field assessment by obstruction in the inferior attitudinal visual fields, due to displaced masks and the exhaled air fogging the test lens or the patient's glasses, resulting in unreliable results.

What does this study add?

Wearing a surgical mask as low as possible to cover the nose with adhesive tape covering the entire length of the superior border is an easy way to prevent fogging and displacement of the mask during the visual field test. It is useful for all patients as it reduces artifacts from the mask, thereby interfering with the visual field results.

Acknowledgement

The present study was supported by a research grant from the HRH Princess Mahachakri Sirindhorn Medical Center, Faculty of Medicine, Srinakharinwirot University (Grant No. 487/2565). The authors would like to thank Asst. Prof. Dr. Suthee Rattanamongkolgul, MD and Dr. Kitsarawut Kwancharee for statistical analysis and Editage (www.editage.com) for English-language editing.

Conflicts of interest

The authors declare no conflict of interest.

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