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The Effect of Different Mask Types Used by Dentists on Oxygen Saturation During COVID-19 Pandemic: Clinical Study

COVID-19 Pandemisi Sürecinde Diş Hekimlerinin Kullandıkları Farklı Tip Maskelerin Oksijen Saturasyonuna Etkisi: Klinik Çalışma

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ABSTRACT Objective: Wearing mask is the most effective prevention measure to limit the spread of coronavirus disease-2019 (COVID-19). Dentistry is one of the professions at risk of contracting COVID-19. The aim of this study was to examine the change in oxygen saturation and pulse rate of dentists who use different types of masks for long hours professionally. **Material and Methods:** One hundred and sixty eight (100 male, 68 female) volunteer dentists were included in the study. They were divided into 4 groups as those using single surgical mask, double surgical mask, surgical masks+face shield and FFP2+face shield. Oxygen saturations and pulses of the volunteers were measured before starting work and after a half day work (3 hours later) by finger pulse oxymeter and results were statistically evaluated. **Results:** Sixty seven (%39.9) of the volunteers wore single surgical mask, 38 (%22.6) wore double surgical masks, 35 (%20.8) wore surgical masks+face shields and 28 (16.7%) wore FFP2+face shields. A statistically significant decrease in oxygen saturation was observed after the use of masks in dentists wearing single surgical mask, double surgical mask, and surgical masks+face shield. There was no statistically significant difference in either the pulse rate or oxygen saturation after using the mask in those who used the FFP2+face shield. **Conclusion:** FFP2 masks did not cause any decrease in users' oxygen saturation. Although surgical masks caused a statistically significant decrease in oxygen saturation, the results did not fall below the physiological limits and were not of clinical significance.

Keywords: COVID-19; dentistry; FFP2 mask

ÖZET Amaç: Maske takmak, koronavirüs hastalığı-2019'un [coronavirus disease-2019 (COVID-19)] yayılmasını azaltmada en etkili önlemdir. Diş hekimliği, COVID-19'a yakalanma riski olan mesleklerden biridir. Bu çalışmanın amacı, profesyonel olarak uzun saatler boyunca farklı tipte maske kullanan diş hekimlerinin oksijen saturasyonu ve nabız hızındaki değişimi incelemektir. **Gereç ve Yöntemler:** Çalışmaya 168 (100 erkek, 68 kadın) diş hekimi dâhil edildi. Çalışmaya katılanlar; tek cerrahi maske, çift cerrahi maske, cerrahi maske+yüz siperi ve FFP2 maske+yüz siperi kullananlar olarak 4 gruba ayrıldılar. Gönüllülerin oksijen saturasyonları ile nabzı işe başlamadan önce ve yarım günlük bir mesaiden sonra (3 saat sonra) puls oksimetreyle ölçülmüş olup, sonuçlar istatistiksel olarak değerlendirildi. **Bulgular:** Gönüllülerin 67'si (%39,9) tek cerrahi maske, 38'i (%22,6) çift cerrahi maske, 35'i (%20,8) cerrahi maske+yüz siperi ve 28'i (%16,7) FFP2 maske+yüz siperi takıyordu. Tek cerrahi maske, çift cerrahi maske ve cerrahi maske+yüz siperi takan diş hekimlerinde maske kullanımı sonrası oksijen saturasyonunda istatistiksel olarak anlamlı bir düşüş gözlendi. FFP2+yüz siperi kullananlarda maskeyi kullandıktan sonra nabız hızında ve oksijen saturasyonunda istatistiksel olarak anlamlı bir farklılık izlenmedi. **Sonuç:** FFP2 maske, kullanıcıların oksijen saturasyonunda herhangi bir azalmaya neden olmadı. Cerrahi maskelerin, oksijen saturasyonunda istatistiksel olarak anlamlı bir düşüşe neden olmasına rağmen sonuçlar fizyolojik sınırların altına düşmedi ve klinik olarak anlamlı değildi.

Anahtar Kelimeler: COVID-19; diş hekimliği; FFP2 maske

In late December 2019, cases of atypical pneumonia began to appear in Wuhan. This virus, which causes severe acute respiratory syndrome, has been named coronavirus 2 (SARS-CoV-2) by Chinese researchers.[1,2] The World Health Organization (WHO) declared the coronavirus disease-2019 (COVID-19) infection as a widespread public health emergency due to its spread and mortality rate of up to 3.4% and declared the disease as pandemic on March 2020.[3,4] As of the date of submission of this paper, the num-

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ber of cases worldwide were 218,946,836 with 4,539,723 deaths according to the data of WHO.[5]

COVID-19 affects different people in different ways. Symptoms are mostly mild, resembling flu-like symptoms and seasonal allergies in about 80% of cases. Less common symptoms are pain and aches, sore throat, diarrhea, conjunctivitis, headache, hyposmia, dysguesia and skin rash.[6] Symptoms are more severe in people with pre-existing chronic diseases such as cardiovascular disease or immunosuppression.[7] Patients with severe symptoms may have to be intubated due to the loss of the breathing ability of their lungs and low oxygen saturation, and unfortunately may even result in death.

Since this disease is transmitted by droplet infection, the most important rules for prevention are "mask, distance and hygiene". WHO advise that people over 12 years should wear mask in crowded environments.[8] There are basically two types of masks used for this purpose: surgical or medical masks and respirators. Medical masks are made of three layers of synthetic nonwoven materials and with a filtration layer in the middle. They can be of various thickness, fluid resistance and filtration rate. Respirators, or otherwise known as filtering face piece (FFP) masks can be of different types such as FFP2, FFP3, N95 and N99. They are designed to protect healthcare workers where aerosol generating procedures are undertaken. The use of masks with exhalation valves is not recommended by the WHO.[9] Because during expiration, viral particles can come out of the valve and cause spread.

In dental procedures, the risk of transmitting the disease to both the physician and other patients by cross contamination is quite high. WHO recommends that health care workers should wear a medical mask in areas where there are patients-any patients, even if physical distancing can be maintained. A respiratory mask should definitely be used, especially during the treatment of a patient with suspected COVID-19, which will generate aerosols.[9]

Although it is known how important masks are in preventing the spread of the disease, the negative aspects of masks are also mentioned from time to time. For example, contamination caused by not changing the mask, skin lesions and irritation as a result of using the mask for long hours.[10] It is stated that the use of masks for a long time reduces the quality of breathing air. Although it is claimed that masks increase the carbon dioxide intake and decreases the oxygen intake during breathing, there is no definite emphasis that the use of a mask increases the carbon dioxide respiration. There are even those who state that long-term use of masks will cause a decrease in lung capacity in the future. Pulse oxygen saturation (SpO_2) is the ratio of HbO_2 in the total hemoglobin in the blood, also called the O_2 concentration in the blood. It is an important bio-parameter for the evaluation of breathing. Today, SpO_2 and pulse can be easily measured simultaneously with finger probes. Oxygen saturation with pulse oximetry measurement is not a substitute for arterial gas measurement, but is a good and practical method for monitoring the spike in O_2 saturation. The aim of this study was to examine the change in oxygen saturation and pulse rate of dentists who use different types of masks for long hours professionally.

MATERIAL AND METHODS

STUDY DESIGN

This prospective study was carried out in Atatürk University, Faculty of Dentistry with the approval of Ethics Committee (decision number: 2021, decision date: 3) in accordance with the principles of the Declaration of Helsinki. During the COVID-19 pandemic process, 168 (100 male, 68 female) volunteer dentists using regular masks in our faculty were included in the study. The volunteers were asked not to take off their masks during a half-day shift. Those who took off their masks even momentarily and those with any systemic disease were not included in the study. Persons with chronic upper and lower respiratory tract disease and those with acute lower or upper respiratory infections were also excluded from the study. Volunteers participating in the study were divided into four groups as those using a single surgical mask, double surgical mask, surgical masks+face shield and FFP2+face shield. All of the FFP2 masks included in the study were duckbill shaped and complied with standard EN 149: 2001+A1:2009 and made sure that the masks fit the face properly. And all surgical

masks were three-layer, non-irritating, latex free disposable ones.

MEASUREMENTS

Oxygen saturations and pulses of the volunteers were measured before starting work, that is, when they started wearing the mask. The measurements were made by a clinical nurse with at least twenty years of experience by finger pulse oxymeter (Contec, CMS50D Finger Pulse Oximeter, USA). The measurements were made after the volunteers were seated for a few minutes and rested. In order to obtain the optimum value in the measurement, the reading was made when the measured value waveform was equal and regular. At this stage, volunteers who reported headaches, ear pain, and discomfort on face and dyspnea were excluded from the study. After wearing mask, volunteers continued their routine work. The measurements were repeated after half a day (three hours later) of work before lunch break by the same nurse who followed the volunteers. At this stage, it was questioned and noted whether the volunteers experienced dyspnea, anxiety, discomfort, headache, and pain in the ear or vision problems. Volunteers, whose measurements could not be repeated in 3 hours were not included the study. The pulse oxymeter was wiped with surface disinfectant after each use as the volunteers were bare-handed during measurement.

STATISTICAL ANALYSES

Statistical Package for Social Sciences (SPSS) 17 package program was used for data analysis. Volunteers were divided into four groups as those using single surgical mask, double surgical mask, surgical masks+face shield and FFP2+face shield. The distribution analysis of the data obtained was analyzed using Kruskal-Wallis and Shapiro-Wilk tests and normal distribution of the data was confirmed. In addition, the paired t-test was used to evaluate whether there was a difference between the subjects and each group in terms of oxygen saturation and pulse rate at the beginning and 3rd hours. The chi-square test was also used for nonparametric comparisons. Pearson's correlation test was used to evaluate the correlation between saturation and pulse. A p value of <0.05 was considered statistically significant.

RESULTS

One hundred male and 68 female dentists participated in the study and their mean age was 31.89±8.52 years (minimum: 21, maximum: 60). The distribution of general findings and mask types are seen on Table 1. Accordingly, 67 (39.9%) of the volunteers wore single surgical mask, 38 (22.6%) wore double surgical masks, 35 (20.8%) wore surgical masks+face shields and 28 (16.7%) wore FFP2+face shields. While 19 (11.3%) of the participants stated that they experienced hoarseness after using the mask, 82 (48.8%) of them stated that they experienced dry mouth.

The differences seen in SpO_2 and pulse depending on the mask type are shown in Table 2 and Figure 1. Accordingly, a statistically significant decrease in oxygen saturation was observed after the use of single surgical mask, double surgical mask, and surgical mask+face shield. And also a statistically significant decrease in pulse was observed in those who wore a single surgical mask and a double surgical mask. However, no statistically significant difference was found in the pulse rate after the use of surgical mask+face shield. There was no statistically significant difference in either the pulse rate or oxygen saturation after using the mask in those who used the FFP2+face shield. In other words, the FFP2 mask did not cause any change in the oxygen saturations and pulse rates of dentists. When all dentists participating in the study were considered, a statistically sig-

TABLE 1: Frequency of general findings.

	n	%
Gender		
Male	68	40.5
Female	100	59.5
Smoking	37	22.0
Alcohol intake	2	1.2
COVID-19 survivors	15	8.9
Mask		
Single surgical	67	39.9
Double surgical	38	22.6
Surgical+face shield	35	20.8
FFP2+face shield	28	16.7
Hoarseness after mask	19	11.3
Xreostomia after mask	82	48.8

TABLE 2: The differences between SpO_2 and pulse values measured before and after wearing the mask in the groups.

Masks	n	SpO_2 (%) before	SpO_2 (%) after	t value	p value	Pulse before	Pulse after	t value	p value
Single surgical mask	67	96.52±1.26	95.94±1.58	2.806	**0.007***	90.81±14.02	87.64±12.48	2.481	**0.016***
Double surgical mask	38	96.89±1.25	95.84±1.65	3.182	**0.003****	90.10±15.48	84.58±11.59	2.828	**0.008***
Surgical masks+face shield	35	97.03±1.25	96.26±1.36	2.686	**0.011***	90.11±14.83	88.51±18.42	0.625	0.536
FFP2+face shield	28	96.64±1.13	96.57±1.17	0.176	0.861	96.39±15.15	98.64±16.25	-0.793	0.435
Total group	168	96.73±1.24	96.09±1.58	4.461	**0.000*****	91.43±14.75	88.96±14.96	2.496	**0.014***

*: p<0.05; **: p<0.005; ***: p<0.0001.

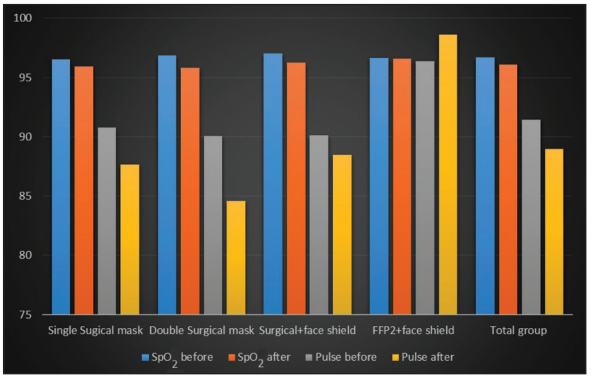

FIGURE 1: The graphic of the differences seen in SpO_2 and pulse depending on the mask type.

nificant decrease in both oxygen saturation and pulse rate was detected.

Nonparametric comparison of the changes seen in SpO_2 and pulse rate depending on the mask types can be seen in Table 3. Accordingly, the group with the least decrease in SpO_2 was those who used FFP2, although it was not statistically significant (p>0.05). Again, the group with the least decrease in pulse rate was the group using FFP2 and this difference was statistically significant (p<0.05). In addition, as seen in the same table, there was no statistically significant difference between the groups in terms of hoarseness and xerostomia depending on the mask types (p>0.05). Also, no correlation was detected between SpO_2 and pulse rate of total group (p>0.05).

DISCUSSION

Unfortunately, many healthcare systems have come to collapse during COVID-19. What is important for healthcare systems is to prevent healthcare staff and their patients from being infected by the corona virus. The WHO mentioned that protective material is essential for all healthcare providers.[11] The standard precautions that healthcare professionals should take are the basic infection control measures that will be used in the care of all patients, regardless of their medical diagnosis or the presence of infection.

Dentistry is one of the professions most at risk of contracting COVID-19. During the care of probable/definite COVID-19 diagnosed patients, hand protection, body protection, respiratory protection and

TABLE 3: Evaluation of nonparametric data depending on mask types.

Masks		Single surgical	Double surgical	Surgical masks+face shield	FFP2+face shield	p value
Xreostomia		43.3%	55.3%	40.0%	64.3%	0.156
Hoarseness		14.9%	15.8%	0%	10.7%	0.107
SpO_2	Unchanged	29.8%	31.5%	28.5%	39.3%	
	Increased	22.4%	13.1%	14.3%	35.7%	0.139
	Decreased	47.8%	55.3%	57.1%	25.0%	
Pulse	Unchanged	2.9%	0%	11.4%	10.7%	0.011*
	Increased	40.3%	31.6%	28.6%	60.7%	
	Decreased	56.7%	68.4%	60.0%	28.5%	

*: p<0.05.

eye protection should be used as protection equipment during the dental care process. Respirator masks such as FFP2 or N95 should definitely be used in procedures with aerosol generation risk, considering that the vast majority of dental procedures create aerosols. Although it is known that aerosols are released into the air with coughing and sneezing, it is stated that many aerosols are emitted into the air even during normal breathing and talking.[12] Apart from these, it is indisputable that dentists are exposed to much more aerosol additionally. It was mentioned that aerosols larger than 50 μm are fall onto surfaces within 1 m due to gravity, aerosols between 10-50 μm can travel 2 m by air flow, aerosols smaller than 10 μm can remain airborne for an extended time and spread by air flow.[13] And in a recent study, it was found that COVID-19 was detected in aerosols up to 3 hours postaerosolization.[14]

Wearing mask alone is not adequate against COVID-19 unless the mask meets certain standards. Dentists are already wearing masks while doing their routine profession and they are also aware of using the mask correctly. It is very important to wear, remove and dispose the mask correctly. Otherwise, it may cause thorough contamination while aiming to protect with the mask. Dentists are advised to follow standard precautions including the appropriate use of personal protective equipment and hand hygiene practices, use of respirator masks, irritant mouthwash solutions before dental procedures, negative air pressure in treatment rooms and disinfect inanimate surfaces.[4]

During the COVID 19 pandemic, there was a dramatic increase in mask use. Most of the healthcare professionals prefer surgical masks as protective equipment. As a matter of fact, we saw in our study that the majority of volunteers preferred surgical masks also. Surgical masks are disposable masks that are fixed to the face by using ties at the back of the head or by using elastic bands behind the ears to cover the mouth, and nose. These masks are mainly used to prevent large particles (larger than 3 μm droplets) containing microorganisms from reaching the nose and mouth, and are not recommended for protection from airborne diseases.[15,16] Surgical masks must be produced in accordance with certain technical standards such as bacterial filtration efficiency, splash resistance, antimicrobial structure and breathability. Surgical masks are divided into 2 classes as Type I and Type II according to their bacterial filtration efficiency specified in European standards. Type II class also has 2 sub-types as splash-proof and non-splash-proof. Type I face masks are not suitable for healthcare professionals' usage.[17]

Particle filtering masks or FFPs are specially designed to protect against smaller sized particles (0.3 μm) in the air, including aerosols. The European Standard classifies respirator masks into three different categories: FFP1, FFP2, and FFP3. FFP2 is comparable to US standard N95. The numbers 1, 2, 3 on FFPs refer to the increasing level of protection going from low (>80%) to medium (>94%) to high (>99%). Respirators must meet certain minimum standards such as efficiency, breathability, structural stability through technical assessments and practical performance tests. All FFP2 masks used in this study were masks produced in accordance with the European Standard (EN 149: 2001).

It was mentioned that protection of respirator masks is 12-16 times greater than surgical masks.[15,18] However, in order for the protection of the respirator mask to be optimum, it is necessary to choose the appropriate size and to test the tightness. After choosing the appropriate mask, the respirator mask can be used up to 8 hours continuously. These masks can be reused for a limited time as long as there is no risk of contamination. However, it should be discarded when the mask is contaminated with body fluids, wet, not properly worn, or breathing through the mask becomes difficult.[16]

Respirators are not easily tolerated due to their very tight fit and are not preferred like surgical masks in intense working tempo. Because dentists already use a continuous mask for their professions, this situation brings many problems from the mask such as conjunctival-eyelid hemorrhage, allergic reactions etc.[19] One of the reasons why respirator masks are not preferred in health institutions may be their high cost. Widmer and Richner found that FFP2 respirators can be sterilized with plasma peroxide and reused.[20]

Before using FFP2 masks, a leakage test should be performed and it should be ensured that they fit on the user's face properly. FFP2 masks are sometimes not ergonomic for everyone. It may cause reaction especially in the nasal bridge and elastic bands can cause jamming and allergic reaction on the contact surface also.[21] For this reason, there are also researchers who recommend the use of FFP2 in combination with 3D printers and custom made face masks.[11]

The filtration rate as well as the fit of mask to the face plays a big role in the safety of the mask.[13,18] Ciotti et al. tested the air-tightness of FFP2 masks and they mentioned that flat-fold respirator masks seem to be better adapted for healthcare workers than hard shell respirator masks.[22] They found that rate of successful tests was higher with flat-fold than with duckbill, or hard shell respirator masks. However, Teesing et al. found that the best fitting respirator masks were the duckbill shaped masks.[23] All of the FFP2 masks used in the present study were duckbill shaped. However the limitation of the present study was lack of the air-tightness tests.

Surgical masks can protect the wearer from the risk of splashes of biological fluids containing viruses, but they cannot provide an airtight seal around the mouth and nose. However, respirator masks completely prevent inhaling aerosols containing viruses. The filtration capacity of FFP2 masks and N95 masks is almost the same. It is known that conventional surgical masks do not protect against high-risk aerosols, even when used in double or more layers. Leung et al. mentioned that surgical masks can also efficaciously reduce viral copies only in large respiratory droplets and aerosols.[24] Villani et al. stated that there is no significant difference between N95 mask and normal surgical masks in protection from viral infections.[12] However, this is of course not valid for all surgical masks. It has been stated that high quality standard surgical masks meeting European Standards (Type II/III) can be as effective as FFP2 masks in preventing viral respiratory diseases.[25,26]

Although there is no evidence to date, it is considered possible that COVID-19 can be transmitted to the conjunctiva by aerosols also.[16] So it is important to use a face shield to protect the faces and eyes of healthcare workers exposed to aerosol. In our study, the majority of the participants were also using face shields. Although the face shield is thought to have no effect on oxygen saturation, in our study, we found that the decrease in SpO_2 levels of those who wear surgical masks+face shield was higher, although not statistically significant, compared to those who only wear masks.

In a recent study established by Samannan et al., they found no major changes in SpO_2 of healthy groups using surgical mask at 5 and 30 minutes.[27] However they found a significant decrease in SpO_2 of patients with severe chronic obstructive pulmonary disease either in rest or in physical activity. But in our study, the number of participants was higher and the waiting time was longer.

Fikenzer et al. mentioned that ventilation, cardiopulmonary exercise capacity and comfort are reduced by both surgical masks and respirators.[28] However, Hopkins et al. do not agree with these findings.[29]

In a similar study conducted on 112 healthcare professionals in our country during the COVID-19 pandemic, no negative effect of the use of masks on health was found. Although oxygen saturation and heart rate decreased after 180 minutes of use in both mask types, these values remained within physiological limits.[30]

As we mentioned before, it is a limitation that no fitting test was performed for FFP2 masks in our study. Other limitations of the study were the low number of FFP2 masks and the lack of long-term follow-up and not specifying the type of surgical masks used in the study. Maybe it would be better if respiratory rate and carbon dioxide levels were measured as well. As a result of this study, while FFP2 masks had no effect on SpO_2 level and pulse rate, surgical masks caused a decrease in SpO_2 level and pulse rate. Since the moistness is high in surgical masks, contamination of the mask increases and it makes breathing difficult. Therefore, surgical masks should be changed frequently when moist. Although FFP2 masks seem to be more difficult to tolerate and preferred because they fit more tightly on the human face

and their tires are tight, especially in duckbill ones, moisture and contamination are much less because they are more distant from the skin. Air permeability is also better. Its filtration capacity is already higher. Therefore, dentists should definitely prefer respirator masks such as FFP2 in terms of protection during all procedures that will cause aerosol release both in pandemic period and outside of pandemic.

CONCLUSION

The most effective method of protecting against COVID-19 is wearing a mask. This study has shown us that the disaster scenarios produced for the mask are not correct. FFP2 masks did not cause any decrease in users' SpO_2 levels. Although surgical masks caused a statistically significant decrease in SpO_2 level, the results did not fall below the physiological limits. Nevertheless, we can recommend that dentists spend some time in the fresh air without a mask after work, away from the crowded environment.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Fatma Çağlayan, Ahmet Berhan Yılmaz;* ***Design:*** *Fatma Çağlayan, Betül Subaşı Aksakal;* ***Control/Supervision:*** *Fatma Çağlayan, Ahmet Berhan Yılmaz;* ***Data Collection and/or Processing:*** *Nezihat Güneş;* ***Analysis and/or Interpretation:*** *Fatma Çağlayan;* ***Literature Review:*** *Fatma Nur Yozgat İlbaş;* ***Writing the Article:*** *Fatma Çağlayan;* ***Critical Review:*** *Ahmet Berhan Yılmaz;* ***References and Fundings:*** *Nezihat Güneş;* ***Materials:*** *Nezihat Güneş.*

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