

Review Article

# A Study on Voice Changes due to Wearing a Mask by COVID-19

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**Abstract** - People worldwide suffer from the long-term pain of having to wear a mask for a long time when fighting a long-term battle with COVID-19. Nevertheless, the situation is even more difficult as people must fulfill their respective roles in all areas of society. In particular, voice actors and announcers who have to deliver their voice through broadcasting are in a situation where they are contemplating whether they should continue to work while wearing a mask or take them off. From that point of view, in this paper, we studied how much difference in voice change between wearing a mask and not wearing a mask is caused when recording through a microphone. Depending on the person, there was a big difference or a little difference in each case, but in general, when not wearing a mask, when wearing a dental mask, or when wearing a KF94 mask, the voice became weaker in that order. There was no difference according to gender, but the younger the age, the less the difference was due to wearing the mask, and the older the age, the greater the change in voice due to wearing the mask. However, for those who usually had a clear voice, there was not much difference between wearing a mask and not wearing a mask. In conclusion, it is judged that among those who use their voice for broadcasting, those with distinct voice energy can record wearing a dental mask.

**Keywords** - COVID-19, Virus, Dental mask, KF94 mask, Voice, Microphone, Broadcasting.

## 1. Introduction

The first case of COVID-19 was reported in China in December 2019, and it has spread worldwide and has continued to the present day in 2022. Since the main transmission route of COVID-19 is transmitted through an infected person's respiratory tract or saliva, masks have become the top priority tool to prevent the transmission of the virus. Of course, washing your hands and keeping your body clean, keeping a distance between people, ventilating the room, and limiting gatherings are ways to help prevent the spread of the virus, but wearing a mask is the most important way. Many people suffer from wearing a mask for a long time because they have to go about their daily activities despite the possibility of transmission of COVID-19. In particular, people who work in a broadcasting station that has to broadcast their voice through a microphone are troubled because they cannot record with a mask on, nor can they record without a mask. People who broadcast using a microphone at a broadcasting station worry about it because they are worried about the change in voice that will be vaguely different when recording with a microphone while wearing a mask. Therefore, in this paper, we tested the change of voice between the case of recording with a mask on and the case without wearing a mask to find out how much difference there is; as for the mask used for the experiment, a KF-94 mask that completely blocks viruses

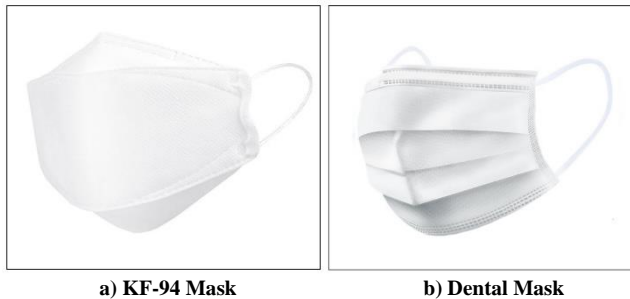
because it has multiple filters and a dental mask used in dentistry were used. A digital SD recorder was used as the microphone for recording. Five subjects, regardless of gender, from teens to 50s, participated in recording voices. As for the recording method, each subject wrote two short sentences prepared 15 cm in front of the microphone without a mask, wearing a dental mask, and wearing a KF94 mask, and recorded each. The recorded voice was analyzed using Adobe's audition program, a voice analysis program.[1]

## 2. Mask

Masks cover the entire face to reveal the face and protect respiratory organs such as the nose and mouth. The masks that cover the nose and mouth generally include a mask for keeping warm, a mask for preventing viruses and fine dust, and a dust mask for preventing asbestos or coal dust in construction sites or mines. In particular, in this time of COVID-19, a mask that mainly covers the nose and mouth is used to prevent the virus from harmful air from the outside. Before the COVID-19 outbreak, people were reluctant to wear masks because there was a perception that people with poor health or criminals wore masks. In particular, it was difficult and frustrating to breathe because I had to wear a mask made with multiple filters to prevent the COVID-19 virus. The US N95 mask, which had strong virus blocking power at the time, is often out of stock, so from January



2021, Korea's KF94 mask began to become famous worldwide. Because there were too many fakes in China's KN95 mask, and the performance of products of the same brand varied widely, KF94 was popularized as an alternative to N95. In the West, many media and experts acknowledge the amazing quality and reliability of the KF94 mask. In addition, the dental mask, which has been used for medical treatment by doctors in dentistry for a long time, has been used in summer, but its use has decreased because the virus blocking power is inferior to that of the KF94 mask. However, it has recently been mutated into Omicron, and the symptoms are weak, so young people use it.[2][3]



**Fig. 1** Types of masks mainly used in the COVID-19 situation

The grade of the mask is divided according to the filter's performance in filtering the air. Masks have been mainly used at construction sites because they block the polluted air from the respiratory system, and sometimes cold patients have used them to prevent the transmission of their virus to others. In particular, in the current COVID-19 situation, the mask is being used as a function to block droplets and aerosols at the same time. There are two main types of masks used in Korea: KF-94 masks and dental masks, depending on the type of filter. The KF series mask is classified into 80, 94, and 99 grades, and the number means that it filters 80%, 94%, and 99% of particles of 0.4 to 0.6  $\mu\text{m}$ . However, since this grade is for blocking fine dust particles rather than a grade for blocking the propagation of droplets, there is no basis for how much it prevents the propagation of droplets of 5  $\mu\text{m}$  particles. However, in the case of a dental mask, as it is known that it can only prevent the spread of droplets by 60 to 70% as a result of a recent test, it is vulnerable to virus prevention in places where there are many people.[4][5]

### 3. Voice change according to the presence or absence of wearing a mask

Korea has long suffered from yellow dust in inland China, which may be intentional. Still, since pollution from industrialization on the east coast of China flows into Korea's west coast, it has been suffering a lot, so a mask to prepare for fine dust is a daily routine. However, since COVID-19, which occurred in Wuhan, China, in 2019, is spread as a virus, it has become more important to block the virus transmitted through droplets, and the mask's main purpose is to block fine dust. Since the coronavirus is a droplet infection,

the virus is released when an infected person sneezes or coughs, and the virus is transmitted to others through the respiratory tract or cornea, etc. In addition, as the virus mutates and is easily transmitted in an aerosol form, the method to protect the respiratory system has become important. In particular, since the virus is spread through conversations between people, it is important to wear a mask more thoroughly in places where there are many people. It is also important to keep a distance from each other. In the beginning, a vaccine for COVID-19 had not yet been developed, and there was no suitable treatment, so it was in danger of falling into a great depression. The COVID-19 virus is a highly contagious virus transmitted through body fluids such as breathing, saliva, and sweat because the transmission method is similar to that of a cold virus. The only thing the general public could do to avoid spreading or contagious the virus was to wear a mask, wash hands well, and keep a distance from other people to prevent breathing. In particular, I had to wear a mask more thoroughly indoors, and later it became a habit, and I fell into an obsession to the point where I thought I should not take it off even in a secluded place outdoors. However, people who work mainly using their voice are worried that their voice will not be transmitted well to others if they wear a mask while working, and they are worried about the efficiency of their work because they cannot show a sincere expression. Of course, everyone uses their voice to work. Among them, the people whose voice is an important means of life are company salespeople, insurance solicitors, and telemarketers, and there are prosecutors, lawyers, professors, and teachers as professionals. There are musical actors and theater actors. Among them, broadcast hosts who record conversations with several panelists in a closed recording booth of a broadcasting station or voice actors who have to record radio dramas with several people gathered in front of a microphone had to think a lot about whether to wear a mask or not. In that sense, in this paper, we analyzed the changes in the voice when wearing the KF-94 mask and dental mask, commonly worn by the public in Korea, and when not wearing a mask through an experiment.[6][7][8]



**a) Broadcasting in progress**



b) Voice actors recording a radio drama  
 Fig. 2 Broadcasters wearing masks and recording

#### 4. Analysis of differences in voice according to whether or not a mask is worn

To analyze the difference in voice according to whether or not a mask is worn, the change of voice when wearing a mask and when not wearing a mask was analyzed through an experiment. For the experiment, a KF-94 mask and a dental mask, which are widely used masks in Korea, were prepared, and an SD digital recorder was used for the voice recorder. Voice analysis was analyzed scientifically using Adobe's audition program. As for the experimental method, 5 subjects from teens to 50s, regardless of gender, wore No mask, dental mask, and KF-94 mask alternately, and the voices recorded with the same tone of voice at the same location were analyzed, respectively and compared. For a voice change experiment depending on whether or not a mask is worn, the two Korean sentences, "Corona 19 can be overcome. Be healthy and happy." was prepared and recorded in Korean. The preceding Korean sentence is [kolona ilgu igyeonael su isseubnida. geonganghasigo haengboghaseyo.] is pronounced.[9][10]

The analysis of these sound frequency components uses the FFT concept to obtain the result.

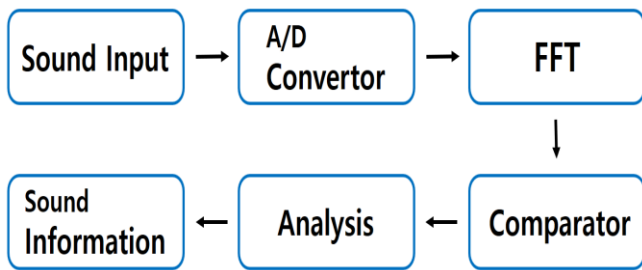


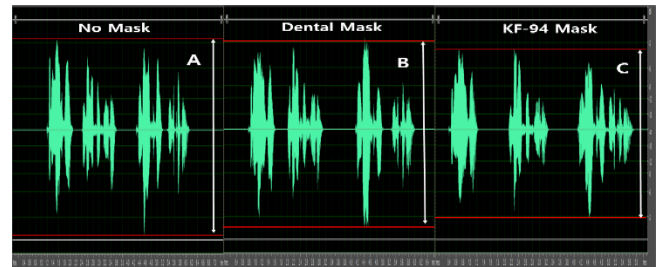
Fig. 3 FFT diagram to obtain sound information

Voice frequency analysis means analysis based on the frequency range included in the human voice. The average frequency required for people to talk to each other is 70 Hz to 3,500 Hz. The audio frequency ranges from the speaker's point of view, while the audible frequency is the range used

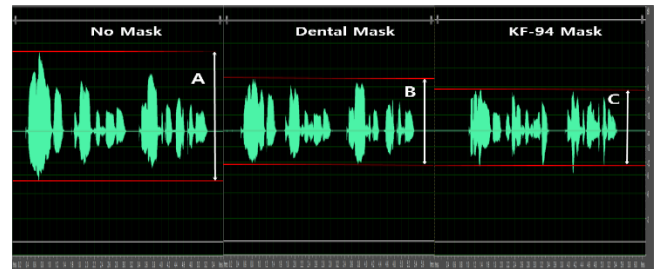
from the listener's point of view. When speaking, the average voice frequency band is slightly different for men and women. The average frequency band of the female voice is 165Hz~255Hz, and the average frequency band of the male voice is 85Hz~180Hz. Although it varies from person to person, the difference in voice frequency between men and women is usually expressed as a frequency band of one-octave difference. Women have twice as much men's voice frequency band.[11][12][13]

#### 4.1. Time domain analysis of voice according to whether or not wearing a mask

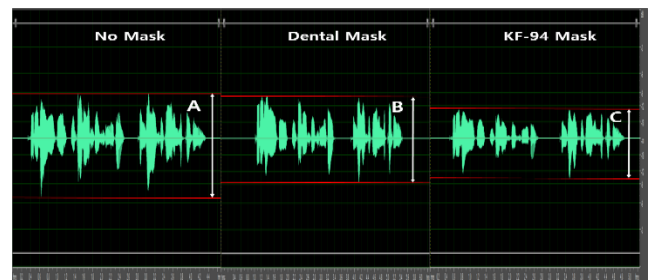
The time domain graph was analyzed to find the change in voice when no mask was worn and when two masks (dental mask, KF19 mask) were respectively worn. In the time domain graph, the horizontal axis is time, and the vertical axis is dB. The time domain graph can confirm the change in the size of the sound to be analyzed over time. In the time domain graph of voice change according to wearing a mask, the left side shows the change in voice when no mask is worn, the middle side shows the voice change when a dental mask is worn, and the right side shows the voice change when a KF-94 mask is worn.[14][15]



a) Time domain graph of a 10's male voice



b) Time domain graph of a 20's female voice



c) Time domain graph of a 30's female voice



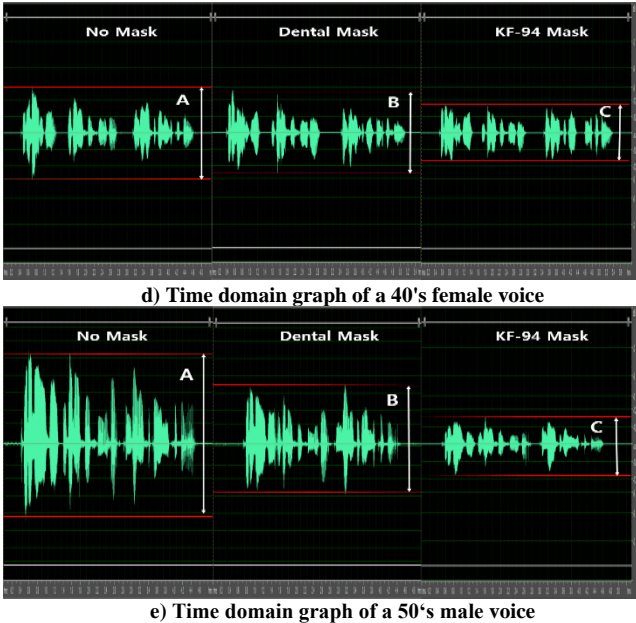


Fig. 4 Time domain graph of voice change according to wearing a mask

Figure 4 is a time-domain graph showing the change of voice between 10's ~ and 50's when they do not wear a mask, when they wear a dental mask, and when they wear a KF94 mask. A is a time domain graph of the voice change of a teenage male. The sound width is stronger than the graph of other age groups, and there does not seem to be much difference between no mask, wearing a dental mask, and wearing a KF-94 mask. B is a time domain graph of a 20's female voice change. The voice change time domain graph of a woman in a 20's female has a smaller pitch than that of a 10's male but shows a larger graph than the graphs of her 30's female ~ 40's female. Also, there was no significant difference in the graph of 10's males when they did not wear a mask, when they wore a dental mask, and when they wore a KF-94 mask. C is a time domain graph of a 30's female voice change. In the time domain graph of voice change of a 30's female, the average sound width was the third smallest after the graphs of those in their teens and twenties. However, like a 10's male or a 20's female, there was no significant difference between a mask, wearing a dental mask, and wearing a KF-94 mask. D is a time domain graph of a 40's female voice change. The time domain graph of voice change of a 40's female is shown as a graph with a smaller overall pitch than the graph for the other people. However, there was a small difference between without a mask and with a dental mask, but the sound width with the KF-94 mask was larger and weaker. E is a time domain graph of a 50's male voice change. In the time domain graph of a 50's male voice change, the difference between when he did not wear a mask, when he wore a dental mask, and when he wore a KF-94 mask was the largest, respectively.[16][17][16][17]

4.2. Spectrogram analysis of voice according to whether or not wearing a mask

The spectrogram graph was analyzed to find the change in voice energy when no mask was worn and when two masks (dental mask, KF19 mask) were respectively worn. The horizontal axis of the spectrogram graph is time, and the vertical axis is Hz. In the spectrogram graph, the energy change for each sound frequency to be analyzed can be confirmed by the difference in the concentration of red light. [18][19]

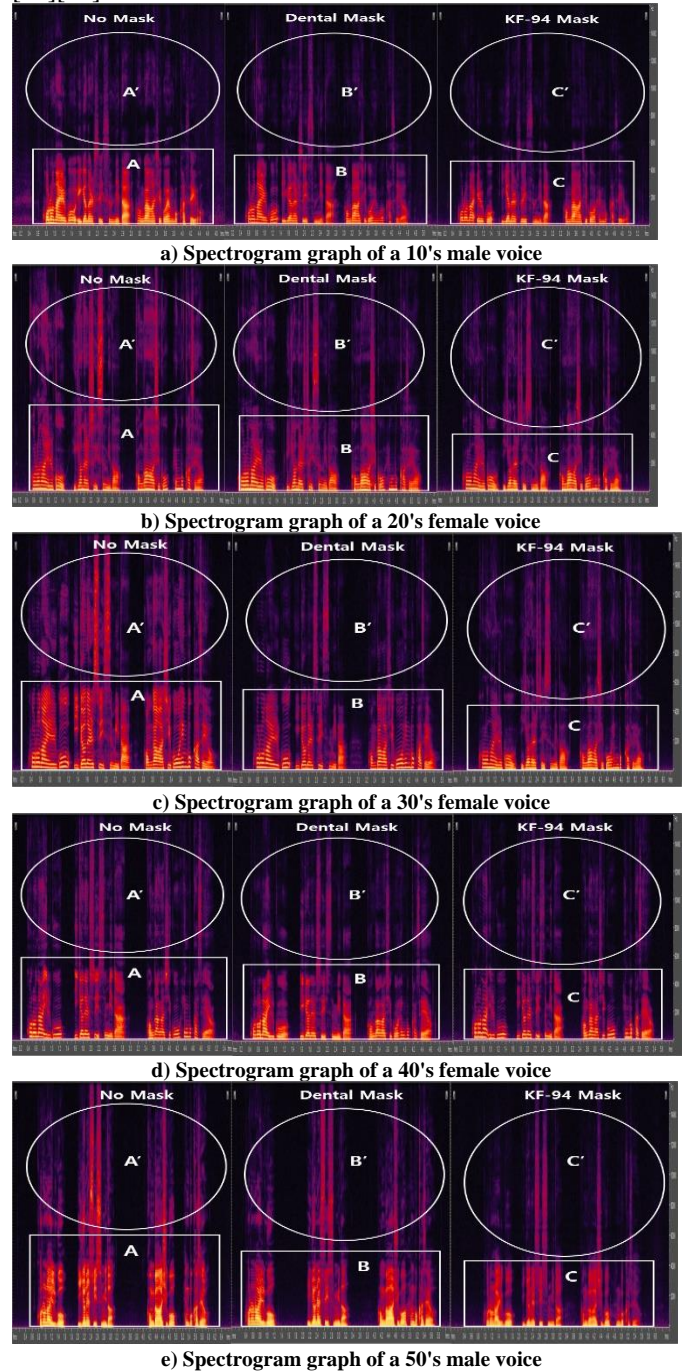
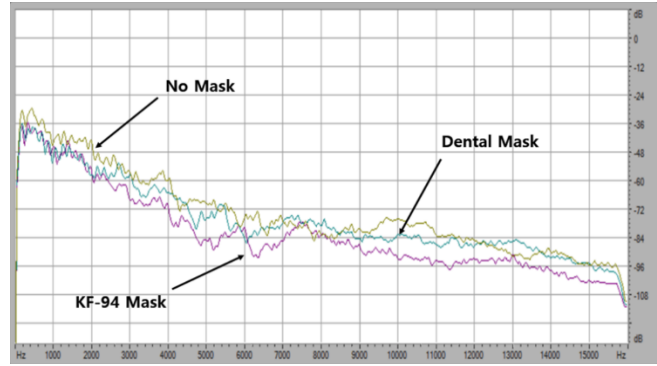


Fig. 5 Spectrogram graph of voice change according to wearing a mask

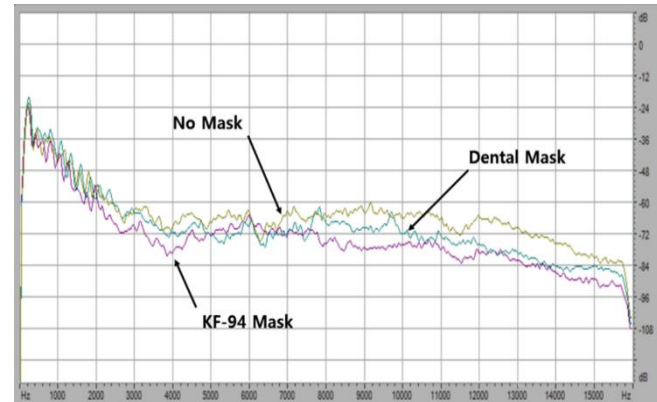
Figure 5 is a spectrogram graph showing the voice energy of 10's ~ '50s without a mask, when wearing a dental mask, and when wearing a KF94 mask. A is the energy change spectrogram graph for each frequency of a 10's male voice, and the frequency band below 4,000Hz, which is the voice frequency band, shows stronger energy than other graphs. The voice energy of a 10's male is strong, so there doesn't seem to be much difference between without a mask, with a dental mask, and with a KF-94 mask. B is a spectrogram graph of energy change by frequency of a 20's female voice. It has slightly weaker energy than the graph of 10's males but shows a graph of stronger energy than graphs of people in their 30s ~ 50s. Also, there was little difference in the graph of 10's males when they did not wear a mask, when they wore a dental mask, and when they wore a KF-94 mask. C is a frequency-specific energy change spectrogram graph of a 30's female voice, showing the third average voice frequency energy following the graphs in their 10s and 20s. There was no significant difference when using the KF-94 mask. D is a spectrogram graph of energy change by frequency of a 40's female voice, showing that voice energy is generally weak among other people. However, the difference in voice frequency energy according to the presence or absence of the mask was larger when the KF-94 mask was used than the dental mask. E is a spectrogram graph of energy change by frequency of a 50's male voice. The difference between without a mask, with a dental mask, and with a KF-94 mask was the largest compared to other age groups.[20]

#### 4.3. Spectrum analysis of voice according to whether or not wearing a mask

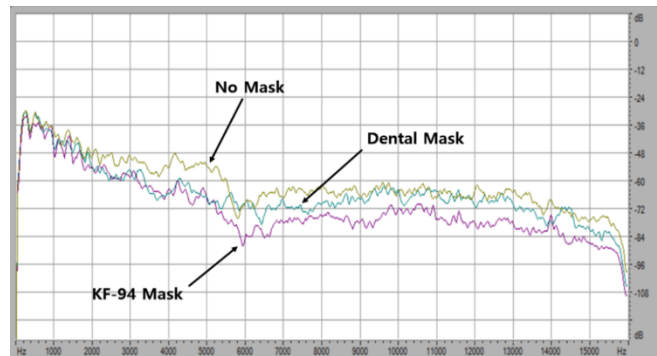
Spectrum graphs were analyzed to compare the voice changes when not wearing a mask and when wearing a dental mask or KF94 mask. The horizontal axis of the spectrum graph is Hz, and the vertical axis is dB. The spectrum graph can compare and analyze the dB for each frequency of the sound to be analyzed. As a method to check the change in the size of the voice by frequency depending on whether or not a mask is worn, the voice recorded without a mask, the voice recorded with a dental mask, and the voice recorded with the KF-94 mask were analyzed using a spectrum graph. In the spectrum graph, to check the change in the size of the voice according to whether or not a mask is worn, the yellow graph is when no mask is worn (No Mask). The green graph is when a dental mask is worn (Dental Mask), and the red graph is KF-94. It is a graph of the change in voice volume by frequency when wearing a mask (KF94 Mask). Figure 6 is a spectrum graph showing the change in voice frequency between 10's ~ and 50s when they do not wear a mask, when they wear a dental mask, and when they wear a KF94 mask. [21][22]



a) Spectrum graph of a 10's female voice



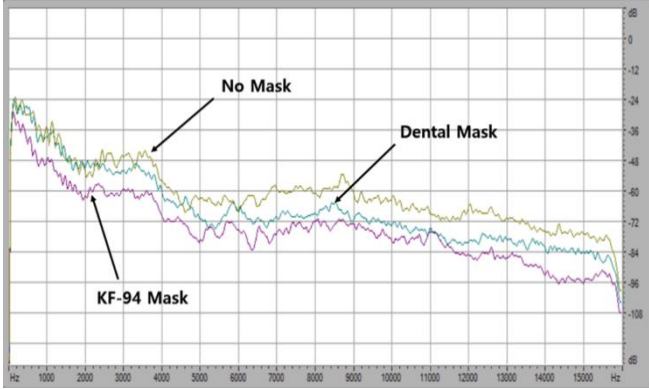
b) Spectrum graph of a 20's female voice



c) Spectrum graph of a 30's female voice



d) Spectrum graph of a 40's female voice



e) Spectrum graph of a 50's male voice

Fig. 6 Spectrum graph of voice change according to wearing a mask

Voice energy changes by frequency according to whether or not a mask is used. The left side of the spectrogram graph shows the voice energy change by frequency when no mask is used, the middle is when a dental mask is worn, and the right side is when a KF-94 mask is worn. A is a 10's male voice frequency change spectrum graph, and the difference in dB for each voice frequency band is more evident than in the graphs of other age groups. B is a 20's female voice frequency change spectrum graph. Although the difference in dB for each frequency is smaller than that of 10's, it shows a larger graph than those in their 30's ~ 50's. Also, there was no significant difference like the graph of 10's when they did not wear a mask, when they wore a dental mask, and when they wore a KF-94 mask. C is a 30's female voice frequency change spectrum graph, which shows the third smallest difference in dB for each frequency following the graphs in their 10's and 20's. There was no significant difference in the 10's and 20's graphs. D is a 40's female voice frequency change spectrum graph,

showing the smallest dB difference by frequency among the graphs of 5 people. However, the difference in dB of sound frequency without a mask, with a dental mask, and with a KF-94 mask was larger when using the KF-94 mask than when using the dental mask. e is a 50's male voice frequency change spectrum graph, and the difference between without a mask, with a dental mask, and with a KF-94 mask was the largest compared to other age groups.[23]

### 5. Result

To study the change in voice due to the mask during the COVID-19 period, the voice change according to the presence or absence of wearing a mask was studied through an experiment for 5 men and women in their 10's ~ 50's. Five test subjects performed the method of confirming the change of voice by recording the sentences presented for the experiment without wearing a mask, wearing a dental mask, and wearing a KF94 mask. The sentence for recording the voice is a Korean sentence saying, "We can overcome Corona 19. Be healthy and happy." to express the meaning in English sentences, 'We can overcome COVID-19. Be healthy and happy.' The Korean sentence is [kolona ilgu igyeonael su isseubnida. geonganghasigo haengboghaseyo.] was read and recorded. Time domain, spectrogram, and spectrum analysis were performed for each recorded voice using an audition program. The duration and width of the voice were analyzed in the time domain, the energy of the voice frequency was the spectrogram, and the spectrum was analyzed to compare the distribution of voice frequencies by bands and overall frequency characteristics.

**<Voice change experiment when wearing a mask>**

[ maseukeu chaavona moagsoli yeonau ]  
Korean pronunciation

**We can overcome COVID-19.**  
[ kolona ilgu igyeonael su isseubnida. ]

**Be healthy and happy.**  
[ geonganghasigo haengboghaseyo. ]  
Korean pronunciation

**Record once with the mask on and once with the mask off.**  
[ maseukeu sseugo ilhoe, beosgo ilhoe nogeumhaseyo. ]  
Korean pronunciation

Fig. 7 Recorded phrases for a voice change experiment with or without mask wearing



As a result of the experiment on the change in voice due to the mask during the COVID-19 period, the voice of most subjects did not show much difference in voice change according to the wearing of the mask in the low-frequency region. Still, as it goes from the middle-frequency region to the high-frequency region, whether the mask is worn or not, There was a significant difference in the transmission power of voice according to age. It can be seen that the younger you are, the less the difference in the size of the voice according to the mask is, and the older you get, the greater the change in the voice according to the difference in the mask. Although there are differences depending on the person, teenagers are the most pronounced vocalizations, so in all cases of wearing a mask, the size of the sound width, voice energy, and voice frequency was visible. People in their 20's have slightly weaker sound width, voice energy, and voice frequency than 10's, but they are still young, so vocalizations

are visible regardless of wearing a mask. Because people in their 30's are still young too, it was the third time after those in their 10's and 20's. However, since aging starts from the age of 40, it was found that vocalization is affected by whether or not a mask is worn. In their 50s, their hearing was weakened, and their voices increased inversely. In particular, when people in their 50s wear a dental mask, their vocalizations do not decrease significantly, but when they use a KF-94 mask, it can be seen that the sound width is significantly reduced. The reason is that the 50s is a time when aging is in progress, and the breathing power decreases. Also, regardless of age, wearing a mask did not significantly affect the change in voice for voices with clear overall frequencies. Rather, such a person did not feel much difference when recording with a dental mask compared to taking the mask off and recording.

Table 1. dB change table for each frequency of voice according to whether or not a mask is worn

Age Group	Content		dB change per Hz									
	Mask	Hz	200	400	600	800	1,000	2,000	3,000	4,000	5,000	10k
10's boy	No-Mask		30	28	42	38	42	48	56	60	70	76
	Dental		36	36	52	48	48	58	58	65	76	82
	KF-94		36	38	52	46	50	60	68	72	85	92
20's woman	No-Mask		24	36	38	36	45	56	62	70	72	66
	Dental		20	36	38	36	45	58	64	72	72	72
	KF-94		24	43	44	40	48	54	68	78	66	76
30's woman	No-Mask		34	40	36	34	42	50	50	54	52	64
	Dental		32	40	36	38	46	56	56	66	66	64
	KF-94		34	42	36	38	50	56	58	64	64	72
40's woman	No-Mask		32	30	36	42	48	58	60	66	64	74
	Dental		32	32	36	44	50	56	60	60	76	76
	KF-94		38	38	38	46	52	59	64	73	76	80
50's woman	No-Mask		24	24	30	38	36	53	46	56	62	82
	Dental		24	30	32	39	38	50	52	62	71	74
	KF-94		30	34	46	50	48	63	60	70	80	80

## 6. Conclusion

In 2019, when COVID-19 originated in Wuhan, China, and slowly began encroaching on the world, people worldwide were terrified. However, because of the coronavirus, everything could not be stopped, so despite the fear, people had to continue their daily lives. As a result, among the professions that require a voice to be used for broadcasting, announcers who deliver accurate information or voice actors who express more delicate breathing and emotions had to be placed in a difficult situation. In particular, recording a radio drama was even more difficult

because several people gathered in a booth in a closed recording studio and had to take off their masks and record in front of a microphone. In the early days of COVID-19, the voice actors took off their masks and recorded when they were making a radio drama, but as one or two people started to be confirmed, the number of confirmed cases increased. In the meantime, the staff suggested that we try to make a radio drama with a mask on, so we started an experiment on the change of voice depending on whether or not a mask is worn. As a result of the experiment, the younger the age, the less the difference in voice change depending on whether or not

the mask was worn, and the voice quality when wearing a dental mask was good enough to be used for broadcasting than the KF94 mask. In particular, since the voice actors are always practicing their vocalizations, there is less change in their voices due to wearing a mask than the general public. However, young people with strong nasal sounds or a thin

and soft voice showed significant changes depending on whether they wore a mask. Furthermore, it was concluded that although most voice actors with clear voices, regardless of age, can record with a dental mask when producing radio dramas, it is better to remove the mask for voice actors with weak voices or strong nasal voice passages.

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