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# Hydrocolloid Application for Increasing the Comfort of N95 Respirators in COVID-19 Wards: A Comparative Study

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**Abbreviations:**

FFRs=Filtering Facepiece Respirators; COVID-19=coronavirus disease 2019; SARS-CoV=Severe Acute Respiratory Syndrome; MERS-CoV=Middle East Respiratory Syndrome; TIL=Total Inward Leakage; CNC=Condensation Particle Counter; FF=Fit Factors; NPUAP/UPUAP=European Pressure Ulcer Advisory Panel classification of pressure ulcers; VAS=Visual Analog Scale

## 1. Abstract

**1.1. Background:** The aim of this study was to explore the efficacy of hydrocolloid application in increasing the wearing comfort of N95 Filtering Facepiece Respirators (FFRs), reducing the occurrence of facial pressure ulcers, and improving the subjective experience of the medical staff.

**1.2. Methods:** The leakage of the FFR was detected before and after hydrocolloid application on the cheeks. Medical staff working in a Coronavirus disease 2019 (COVID-19) ward were divided into an observation group using hydrocolloid and a control group without hydrocolloid. The incidence of facial pressure ulcers, fogging of protective goggles, and the subjective experience of the subjects were evaluated.

**1.3. Results:** Hydrocolloid was not found to increase the leakage of FFRs. The incidence of facial pressure ulcers was significantly reduced in the subjects that received hydrocolloid, while the fogging time of the protective goggles was extended. The wearing comfort of the FFRs was reported as higher in the group that received hydrocolloid.

**1.4. Conclusions:** Hydrocolloid application prior to FFR-wearing can effectively reduce the occurrence of facial pressure ulcers and improve comfort.

## 2. Background

Since the outbreak of COVID-19, a series of health-care worker selfies, showing their faces bruised and indented from masks, filtering facepiece respirators (FFR) and goggles, has gone viral. These selfies have come from around the world and highlight the effect that personal protective equipment (PPE) has when worn hour after hour, day after day. COVID-19 has very high infectivity, higher than both Severe Acute Respiratory Syndrome (SARS-COV) and Middle East Respiratory Syndrome (MERS-CoV) [1, 2]. Healthcare professionals working in hospitals are at particularly high risk of infection, due to their direct contact with COVID-19 patients and the most effective methods identified to prevent viral transmission are proper mask wearing and adequate hand washing [3]. Proper use of PPE by medical staff reduces the risk of transmission; this includes continuous wearing of N95 or KN95 FFRs.

As mentioned in a recent article by Wu et al. when facial PPE is worn continuously for multiple hours, the constant pressure on the skin can cause inflammation, pain, and even skin ulcers on the compressed areas [4]. Other reported issues include fogging of the safety goggles and discomfort which may impact the clinical

work. In addition, as contact transmission has been proposed as one possible transmission route, facial pressure ulcers can increase the risk of viral infection [5].

In this study, we investigate the application of hydrocolloid prior to mask donning at a single center in Wuhan, China, the center of the pandemic, with the hope of providing information that could improve the care of medical workers wearing facial PPE around the world.

## 3. Methods

### 3.1. Respirators

The N95 FFR (3M 1860, St Paul, MN, USA) was the most widely used FFR model in the COVID-19 ward of Union hospital, Tongji Medical College, Huazhong University of Science and Technology. Because of limited resources, the standard size FFR was selected for the study. Hydrocolloid (Comfeel 3110, Coloplast, Hungary) was cut to 2*10cm size to fit the face shape (Figure 1).


**Figure 1a:** 3M-1860 masks

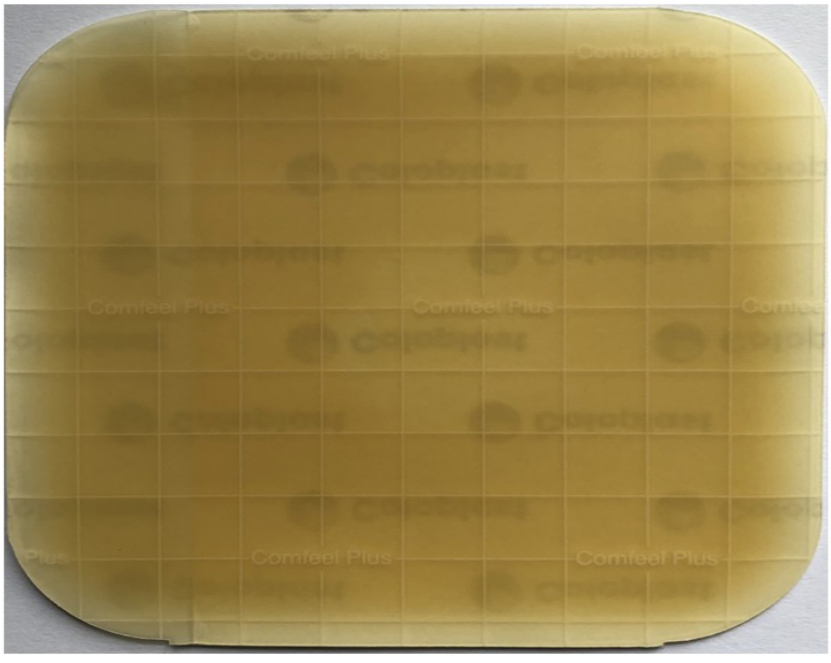


**Figure 1b:** Hydrocolloid

### 3.2. Total Inward Leakage (Til) Testing

TIL testing was performed in collaboration with the School of Public Health, Tongji Medical College, Huazhong University of Science and Technology. Briefly, TIL was measured using a condensation particle counter (CNC). After cleaning the face, five subjects wore N95 FFRs directly on the face. After 5 minutes for adaption to the face, the subjects took seven 60-sec exercises in the following order: normal breathing, deep breathing, moving the head side to side, moving the head up and down, talking, bending over, and normal breathing. The ratio of the particle concentration inside the FFRs to the outside concentration was calculated. After a 60-min rest, the subjects cleaned their faces again, applied a 2*10cm hydrocolloid covering the cheeks and nose, and repeated the FFR-wearing and other steps above. Fit Factors (FF) was calculated as the reciprocal of TIL.

### 3.3. Evaluation of Facial Pressure Ulcers and Fogging Time of Goggles

Twenty medical staff working in the COVID-19 ward in the West Hospital of Union Hospital, affiliated with Tongji Medical College of Huazhong University, were recruited as subjects. They were randomly equally divided into two groups the N95 group (control) and the H+N95 group (observation). In the H+N95 group, participants with dry faces applied 2*10cm hydrocolloid on the cheeks and noses before wearing an N95 FFR and other PPE like goggles and protective clothing. Participants in the N95 group wore PEE without using hydrocolloid. Each subject worked 4-6 hours a day, for one week. The grade and location of pressure ulcers for each subject was recorded according to the European Pressure Ulcer Advisory Panel classification of pressure ulcers (NPUAP/UPUAP) [6]. The effect of using hydrocolloid on reducing facial pressure ulcers was evaluated. In addition, the time from non-fogging to fogging was measured daily for every subject to assess the fogging time of the goggles and whether hydrocolloid could extend the fogging time. Once the subjects experienced facial pressure ulcers, they were excluded from the observation and treated with professional care.

### 3.4. Assessment of The Subjective Experience of the Participants

All subjects completed a questionnaire assessing pain, comfort, breathing resistance and impact on work in order to assess the subjective experience of each group. Pain was measured with the Visual Analog Scale (VAS). Comfort level was graded on three levels, 1 for comfortable, 2 for unnoteworthy and 3 for uncomfortable. Breathing resistance was graded on three levels, 1 for mild, 2 for moderate and 3 for severe. The impact on work had four grades, 0 for none, 1 for mild, 2 for moderate, and 3 for severe.

## 4. Statistical Analyses

Data were analyzed using SPSS19.0 software. A T test was conducted to compare age, grades of pressure ulcers, and subjective experience between the two groups as well as FF results before and after hydrocolloid application. A nonparametric U test was used to compare the fogging time of the goggles between the two groups. P value of $<0.05$ was considered statistically significant.

## 5. Results

The FF results of wearing N95 FFR of five subjects before and after hydrocolloid-application are shown in (Table 1). Although FF after hydrocolloid application was slightly higher than without, no statistical significance was noted between before and after hydrocolloid application.

In terms of subject demographics, no significant difference was found between the sex and mean age of the two groups. Facial pressure ulcers appeared on all participants in the N95 group, with seven of these being grade 2 and three grade 1. In contrast, only four participants in the H+N95 group experienced ulcers, all of which were grade 1 nasal bridge pressure ulcers. The difference between the two groups was statistically significant (Figure 2). Of note, all subjects in the N95 group had to be removed from the study prior to study completion as they required treatment for their pressure ulcers. Only three subjects in the H+N95 group terminated their observation prior to study completion, at 5, 5 and 6 days, respectively. As previously mentioned, all subjects with facial pressure ulcers were excluded from observation and received professional care.

When assessing fogging time, the N95 group had a summed person-time of 44 and a fogging time average of 190 minutes (120-270 min). In the H+N95 group the summed person-time was 65 and the average fogging-up time was 209 min (150-300 min). Thus, application of hydrocolloid before FFR-wearing significantly extended the fogging time.

In terms of subjective experience, the two groups had significant differences in all aspects including pain, comfort, breathing resistance, and impact on work. The H+N95 group had a better overall experience than the N95 group (Table 2).

**Table 1:** Fit factor before and after hydrocolloid application

| Subjects Number | Fit Factor (FF) | | T-value | P-value |
|---|---|---|---|---|
| | Before | After | | |
| 1 | 117 | 124 | 0.907 | P>0.05 |
| 2 | 150 | 152 | | |
| 3 | 154 | 153 | | |
| 4 | 143 | 148 | | |
| 5 | 170 | 166 | | |

**Figure 2a:** Pressure ulcers in the N95 (control) group

**Figure 2b:** Pressure ulcers in the H+N95 (observation) group

**Table 2:** Comparison of pressure ulcers, fogging time, and subjective experience between the N95 (control) group and the H+N95 (observation) group

| | N95 (N=10) | H+N95 (N=10) | T-value | P-value | N95 (P-T=44) | H+N95 (P-T=65) | U-value | p value |
|---|---|---|---|---|---|---|---|---|
| Male | 4 | 4 | | / | 190±30.99 | 209±30.69 | 3.065 | <0.05 |
| Female | 6 | 6 | | | | | | |
| Age (years) | 30.3±4.99 | 29.8±6.25 | 0.195 | >0.05 | | | | |
| Pressure Ulcers (grade) | 1.7±0.48 | 0.4±0.52 | 6.091 | <0.05 | | | | |
| Fogging Time (min) | | | | | | | | |
| VAS | 4.3±0.95 | 0.6±0.84 | 11.05 | <0.05 | | | | |
| Comfort | 2.2±0.42 | 1.3±0.48 | 5.014 | <0.05 | | | | |
| Breathing Resistance | 2.0±0.47 | 1.1±0.32 | 5.014 | <0.05 | | | | |
| Impact on Work | 2.8±0.42 | 1.0±0.67 | 7.216 | <0.05 | | | | |

## 6. Discussion

COVID-19 has high airborne transmission and high pathogenicity, hence, correct use of N95 FFRs can efficiently reduce the risk of exposure of medical staff. [7] Surgical masks are not able to provide substantial protection against aerosol particles less than 50nm or virus. [8, 9] The most commonly used N95 FFRs include the cup type and the fold type. Prior research confirmed that cup-type respirators have higher effectiveness than the fold type. [10] Al-

though the 3M-1860S N95 FFRs are considered to have the most optimal mask fit and better filtration efficiency than the 3M-1860, [6] due to the severe PPE shortages during the COVID-19 pandemic, we opted to use the more readily available 3M 1860 with a standard size. In addition, although a large number of domestic fold-type KN95 FFRs were used in clinical work they were not included in this study as they might not be recognized by national centers for disease control and prevention.

Leakage of N95 FFRs mainly comprises of face-seal leakage and filter penetration. [11, 12] In this study, any compounding effect due to mask material was eliminated as the same type of masks were used before and after hydrocolloid application. Our results highlighted hydrocolloid enhanced the adhesion between the face and the respirators without compromising the face-seal or influencing facial expression. It should be noted that the unique facial features of each subject had an impact on face-seal leakage, and, hence, it is imperative to take personalization into account when attempting to lessen respirator leakage [10,13,14,15].

Use of N95 FFRs reduces the transmission of respiratory viruses, particularly for medical staff treating COVID-19 patients. Such respirators have a better fit and higher filtration efficiency than surgical masks, [16] but are less comfortable and more prone to increasing the temperature and humidity of the face. [17] In addition, wearing respirators for a long time causes other discomforts including a rise in breath resistance, heart rate, and skin temperature. [18] Although the metal nasal clips on N95 FFRs improve the adhesion of respirators they also increase the contact pressure, making it easier for the skin to break out with fissures and local pressure ulcers [19]. Factors such as age, prior chronic skin conditions, sensory impairment, and hypotension, might increase the risk of pressure ulcer formation. [20] In our study, varying stages of facial pressure ulcers appeared on all subjects in the group without hydrocolloid. The discomfort of wearing the respirator not only affected subjective comfort but also caused more facial movement, increasing leakage and raising the risk of infection. [19] More facial movement can reduce the face-seal and make goggle more likely to fog when breathing. The average time of fogging up in the hydrocolloid treating subjects was significantly longer than the control group. Prior research identified that the nasal bridge is the most vulnerable to pressure ulcer formation, followed by the cheek [21].

In terms of prior research, one report found no obvious benefit of applying foam dressings with different thicknesses in preventing facial pressure ulcers in patients under non-invasive mechanical ventilation. [22] Contrary to this study, our study found that hydrocolloid application significantly minimized the risk of facial pressure ulcer formation on both the nasal bridge and cheeks. Of the ten subjects treated with hydrocolloid only four experienced ulcers, all of which were grade 1. In the control group all ten subjects experienced ulcers, and these ulcers were more likely to be of higher grade. Prior results from a study that used hydrocolloids to decrease pressure ulcer formation noted a decrease in occurrence of 79%, which is in agreement with our results [23].

As previously reported, respirators with better fit, comfort and temperature control are more comfortable for medical staff. [16] However, in COVID-19 wards with air-sealed surroundings and no air conditioners, any discomfort including the pain caused by facial pressure ulcers, the fogging of goggles, increased breathing resistance, and other subjective experiences can interfere with the daily duties of the medical staff. Our research showed improvement of all these issues, including a reduction in the occurrence of facial pressure ulcers and an enhancement of comfort, making the overall experience of wearing a respirator more pleasant. Overall, adjuvant therapies, such as hydrocolloids, have the potential to improve the comfort of respirator wear while simultaneously decreasing pain and ulcer formation in the health-care workers currently fighting against this pandemic.

## 7. Conclusions

Our research improved the above-mentioned problems to reduce the occurrence of facial pressure ulcers and enhance comfort, which made workers the safety work accompanied by a pleasant mood. Therefore, it was worthy of popularization that using hydrocolloid before wearing N95 FFRs among medical staffs of respiratory infectious diseases during this COVID-19 pandemic.

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