

Short Note

Development of an N95 compatible full-face mask

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Introduction

A personal protective equipment (PPE) of level 2 (the wearing of both goggles and an N95 mask in our clinic) is necessary for the medical examination in patients with COVID-19. However, when an N95 mask attaches to face so that there is no leak, breathing is unexpectedly hard, and the long-time work is difficult. In Japan, there is the severe current situation that N95 masks are not available, and many hospitals have been running short of N95 masks as well as other PPE. Therefore, as having both function of the masks and goggles, we converted a snorkel mask (full-faced type) to an N95 compatible full-face mask according to the procedure reported by Stanford University Prakash Lab¹.

Materials and Methods

1) Preparation of a full-face snorkel mask, viral filters and the 3D-printed adapter

Today, wide variety of full-face snorkel masks is commercially available. We purchased a full-face snorkel mask (Zenoplige, China) from Amazon Japan on-line shop (Fig.1A). The original mask has a foldable snorkel pipe at the top edge of the ventilation port. Air circulation inside the mask is controlled by a set of one-way valves placed near the nosepiece, which allows one-way circulation of air. This mask features a simple exhale valve at the mouth area, which is usually closed in the water. Important point is that inhale and exhale pathways are separated (Fig.1B). In-line viral filters can be adapted to mount to the 3D-printed part (Fig.1C). We used an ISO standard 22mm OD viral filter (510-014, BSF104) because that has the same ratings as N95 masks (Fig.1D). The computer-aided design (CAD) data of the adapter is shown in Figure 2.

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Fig. 1 **A:** An original full-face snorkel mask. **B:** Air circulation inside the mask: a blue line indicates an inhaled flow, and orange lines indicate exhaled flows.

C: The 3D-printed adapter. **D:** An in-line filter

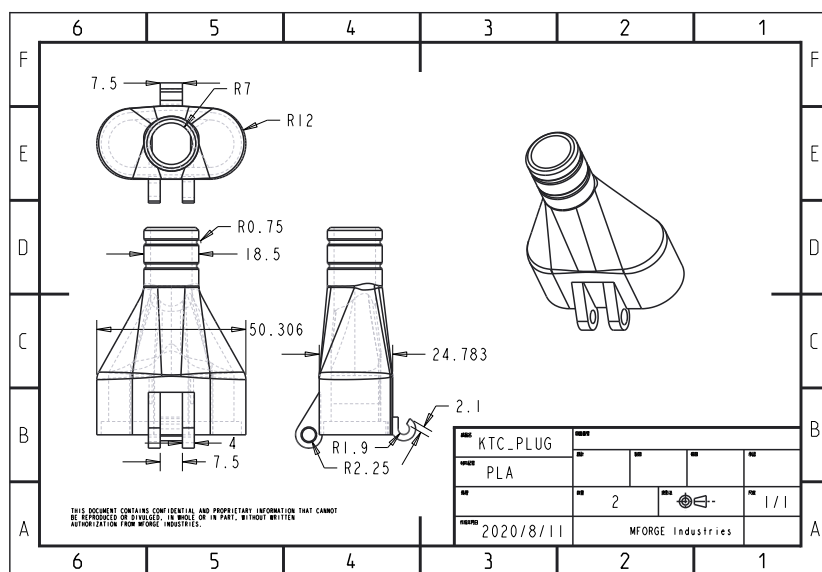


Fig. 2 The CAD data of the 3D-printed adapter

2) Assembly of the parts

We removed a snorkel pipe and attached the 3D-printed part, which has a latch so that air-tight connection is achieved. Then, the viral filter was introduced to the opposite side of the adapter, which has two O-rings (Fig.3).

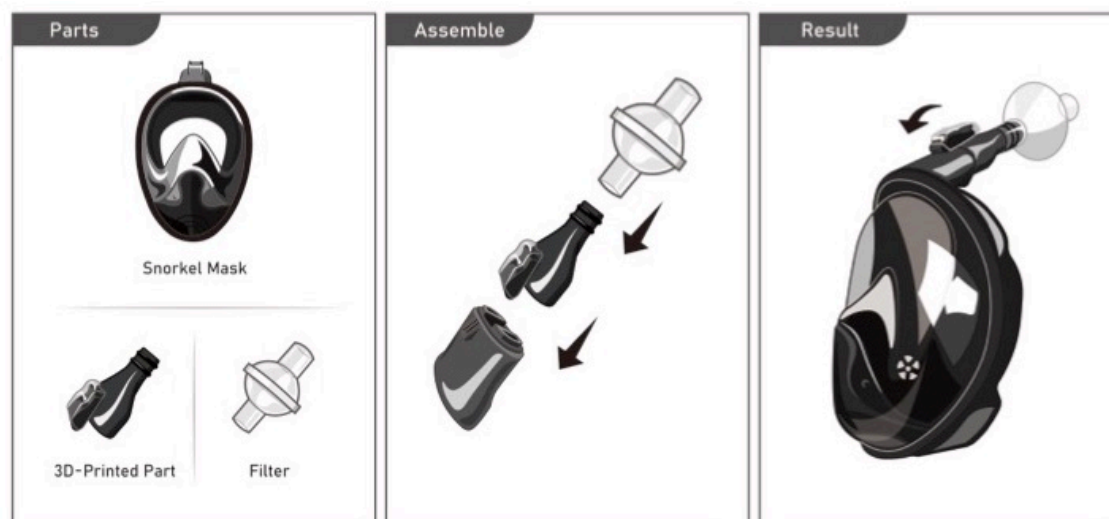


Fig. 3 Assembly of the parts: a latch is put on the 3D-printed flare-out part, connected to the top edge of the ventilation port with the filter placed on the other side.

Result and Discussion

We developed a full-face mask with a viral filter by using a commercially available snorkel mask (Fig.4). In this procedure, the 3D-printed part, by which a viral filter was connected, was essential to fulfill biological safety. To obtain clinical validation, we have to do some tests: sealing capacity, filter performance, pressure drop, CO₂ accumulation, and clinical usability¹⁾. In the clinical setting, it is also necessary to establish a decontamination procedure such as autoclaving, bleach emmersion, and ethanol immersion. The CDC recommends that a set of promising conditions for inactivation of SARS-Cov-2 on N95 mask, which include temperatures between 70-85°C, humidities between 50-85%, and processs times of at least 60 minutes²⁾. The moist heat decontamination method would also be applied to the present mask without modifying the material. We also take into account the way of communication through the mask, especially in noisy condition, because the full-face snorkel mask can significantly muffle the user's voice. In order to solve this problem, a mobile application was created

to relay audio from a Bluetooth® microphone inside the mask to the mobile phone speaker¹⁾.

At present, the device is not approved for clinical use in Japan. However, we believe that this trial is very important during mask shortage in the era of COVID-19 pandemic.



Fig. 4 Complete of an N95 compatible full-face mask

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Conflict of interest

We declare no conflict of interests for this manuscript.

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