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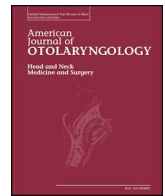
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Smartphone-enabled wireless otoscope-assisted online telemedicine during the COVID-19 outbreak

Dear Editor:

Coronavirus disease 2019 (COVID-19), a new infectious disease in humans, is characterized by respiratory symptoms and human-to-human transmission [1]. The number of the confirmed cases of COVID-19 is rising sharply, and the World Health Organization (WHO) has declared that it can be considered as a pandemic on March 11, 2020 [2]. COVID-19 epidemic has caused disastrous consequences all over the world. As of March 30, 2020, WHO reports that 693,224 people have been diagnosed with COVID-19 worldwide, with 33,106 deaths, including 200 countries and territories, and 82,447 of these cases in China [3].

As an integral part of the respiratory system, the nasal cavity and throat may become susceptible to the virus infection. Swabs sampled from the mid-turbinate, nasopharyngeal, and throat of the COVID-19 patients have been detected the 2019 novel coronavirus, with a higher viral load in the nose [4]. Therefore, the department of otolaryngology is considered to be a high-risk department for COVID-19 [5]. Disasters and pandemics present extraordinary challenges for the healthcare system [6]. During the rampant spread of COVID-19, most hospitals have suspended routine otolaryngology outpatient services in China, retaining only emergency services. Some clinics also shuttered their doors and delivering services only via the non-contact method in the USA [7]. Local health authorities recommend medical care online to meet people's medical needs. The current COVID-19 pandemic reminds us of the importance of telemedicine to prevent cross-contamination [8].

Telemedicine in otolaryngology has a long history [9]. However, otolaryngology is under a complicated anatomical structure. Lacking specialized medical expertise, many patients cannot clarify their clinical signs and symptoms accurately. As a result, otolaryngologists sometimes have to make a diagnosis online or even give therapeutic advice in minimal information, resulting in an inadequate diagnosis.

With the increased popularity of smartphones, the smartphone application is increasing in otolaryngology clinical practice [10]. The smartphone-enabled otoscope (SEO) is emerging a new electronic device in recent years. Using this device with a dedicated application, doctors can quickly investigate the patient's external auditory canal and tympanic membrane. Previous studies have shown the value of the portable devices not only as a convenient diagnostic aid but also as a teaching adjunct for the pre-clinical medical students [11,12]. However, smartphone-enabled wireless otoscope-assisted online telemedicine (SEWOAOT) has not been explored during the COVID-19 outbreak. To contain an epidemic, most people like to stay at home and try to minimize going out. Also, a proportion of people have quarantined in an isolation centre or their home for medical observation. In these situations, SEWOAOT can provide an excellent solution, delivering online otolaryngology services.

We encouraged patients to be involved in the SEWOAOT via two

avenues. On one side, our department delivered online outpatient services to respond to the patients' questions. If the patient seeking medical consultation has chronic ear symptoms with a long medical history, we recommend that the patient involves this project. On the other hand, part of emergency patients participated in an online follow-up. For instance, a 5-year-old boy visited our hospital complaining of ear pain in the middle of the night. This patient was diagnosed with acute otitis media, and was treated with orally administered antibiotics, and was told to take part in voluntary online revisiting at home without exceptional circumstances.

Mebird M9pro wireless otoscope (Black Bee Intelligent Manufacturing (Shenzhen) Technology Co., Ltd.) can be adapted to any smartphone using wireless fidelity. The smartphone needs to download a dedicated app according to the operating system from the app store. The built-in 3-megapixel camera can offer a picture with 2048×1536 pixels resolution and a 480×480 P video (Fig. 1.). The device can be purchased for 250 RMB (\$35) from multiple e-commerce websites, which can be delivered by courier to customers except for Hubei Province from one to three days. Depending on the instruction manual, the patient can smoothly perform the otoscope to examine the ears by oneself (Fig. 2.). The children need their parents' help for examination. The patient sent the images or video taken by the smartphone via WeChat group to doctors. After got the images data, the otolaryngologists made a diagnosis and provided real-time feedback. WeChat, the most popular social media in China, plays a critical role in telemedicine services. Since February 15, 2020, we have preliminary serviced 12 patients via SEWOAOT. There were 5 males and 7 females, with an average age of 28 years (range 4–58 years). Among them, 3 cases of acute otitis media, 2 cases of traumatic tympanic membrane perforation, 2 cases of mycotic otitis externa, 2 cases of cerumen impaction, 1 case of acute external auditory canalitis, 1 case of external auditory canal trauma, and 1 case of post-operation of external auditory canal cholesteatoma. We ask patients to rate their satisfaction with SEWOAOT ranging from dissatisfied, somewhat satisfied, and very satisfied. They were dissatisfied (0, 0%), somewhat satisfied (2, 16.7%), and very satisfied (10, 83.3%). Overall, we have received excellent feedback for participation.

Mandavia et al. performed a cross-sectional study, screening ear disease in Nepal, and concluded that an SEO is a potent tool in the diagnosis of ear disease and the decision for onward referral [11]. Hakimi et al. used SEO for training medical students instead of the traditional otoscope [12]. They found that the students were more confident in identifying the anatomical landmarks of the middle ear. However, a recent study had shown that it had not proved the effectiveness of SEO when local health care workers were examining the children. It potentially relates to insufficient training and education of local medical personnel [13].

SEO in this paper offers a better imaging quality than the previous product. The device also has a directional gyroscope which can keep a

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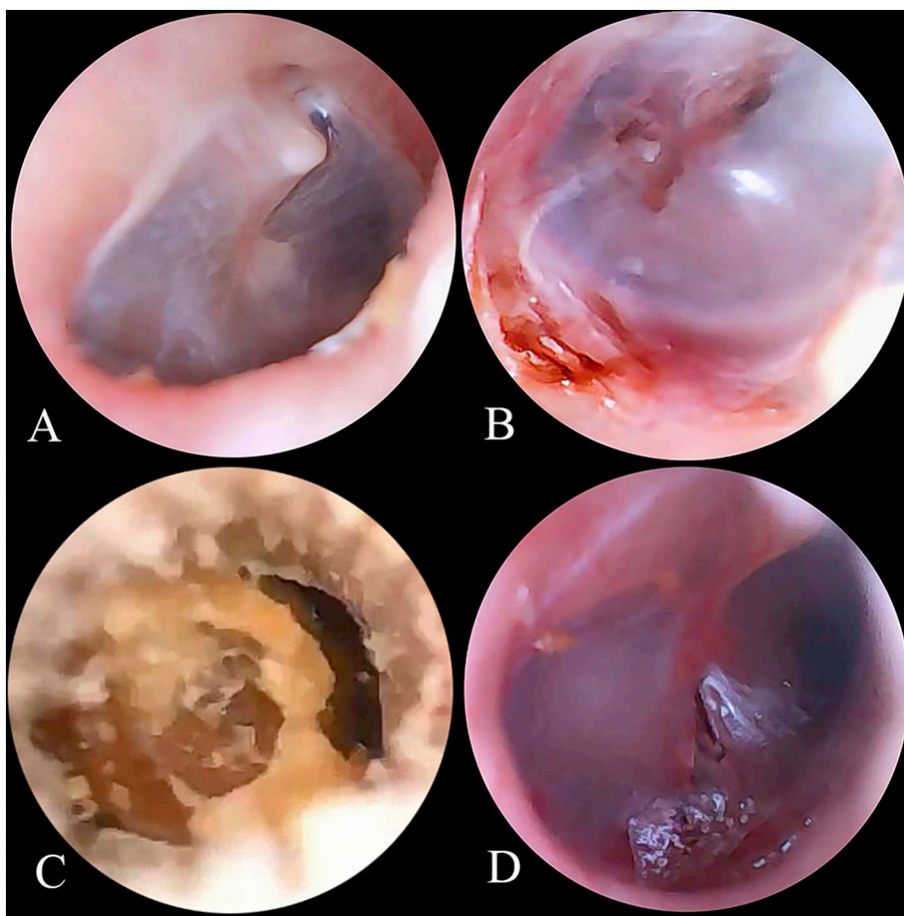


Fig. 1. Photograph showing the edited image of the tympanic membrane taken by the patient's smartphone with the wireless otoscope. A: Normal tympanic membrane (right ear); B: post-operation of external auditory canal cholesteatoma (right ear); C: cerumen impaction (right ear); D: traumatic tympanic membrane perforation (right ear).

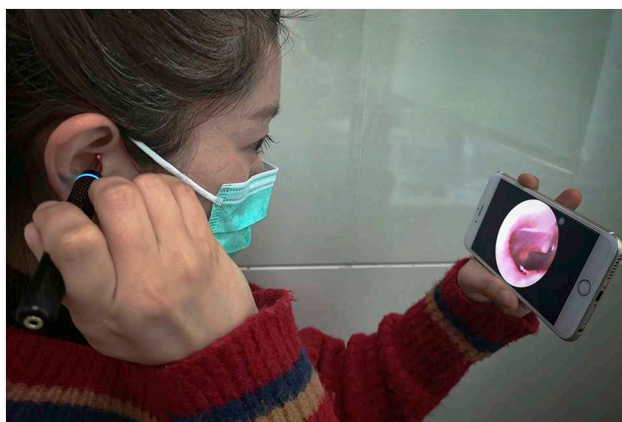


Fig. 2. A woman examined the tympanic membrane of the right ear with a smartphone-enabled wireless otoscope.

constant view angle when the machine body rotates unstably. The technological progress makes it possible to perform a self-examining. However, SEWOAOT also has disadvantages. In some remote rural areas of China, smartphone and internet use remains restricted. SEO is not convenient enough for older people. Nevertheless, SEWOAOT has great significance for preventing human cross-infection during the infectious disease outbreaks.

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Declaration of competing interest

The authors declare that they have no conflict of interest.

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