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Review Article

During and post COVID-19 pandemic: prevention of cross infection at dental practices in country with tropical climate

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ABSTRACT

Background: *COVID-19 has been regarded as a new pandemic in the world. This disease is highly contagious and can be transmitted easily through droplets and air. This matter is considered as a red flag to all dentists all over the globe. Until today, there is only a few specific guideline in regards to dental practice during and after the pandemic. The protocol only revolves around the limitation of patients' appointments and using level 3 personal protection equipment. There is no specific mention on the preparation method of the practice room especially in Indonesia.* ***Purpose:*** *This study aims to review literature on infection control in dental settings during COVID-19 pandemic and discuss possible recommendations based on available evidence.* ***Review:*** *The review also discussed the background of COVID-19, transmission, clinical findings, physicochemical properties, and cross infection in dental practice. Despite the usage of personal protective equipment, the rooms need to be set to specific requirement to reduce contamination inside the room. Until today, COVID-19 transmission must be prevented with the best method available.* ***Conclusion:*** *No single protocol may fully guarantee the safety of the patients and dental workers. We suggest to combine the protocol listed above to minimize to self and cross-contamination 'new normal' practice.*

Keywords: *COVID-19; cross infection; dental practice; prevention; room disinfection*

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INTRODUCTION

Coronavirus infection diseases (COVID)-19 is a new strain of human coronavirus (hCoV). WHO previously termed this virus as 2019 novel coronavirus (2019-nCoV). On February 11th, 2020, WHO introduced a new term for this novel coronavirus known as Coronavirus disease (COVID 19).[1] The coronavirus is not a new virus recorded in history. It was first described in 1931, by Schalk and Hawn as a new respiratory disease. When it first spread in North Dakota, this virus infected newborn chicks, causing gasping and listlessness.[2] The term human coronavirus (hCoV) had been described in 1960s, published in BMJ 1965 by a group of researchers led by virologist David Tyrrell. The team found a strange virus, referred as B814 after studying nasal swab. This new virus is unrelated to any previously known human respiratory tract virus.[3]

In Indonesia, the first two cases of COVID-19 was first reported in March 2nd, 2020 from Depok, West Java. And until May 9th, 2020 data shows the number of confirmed cases as 13,112 cases and 943 death. Mortality rate of COVID-19 in Indonesia was 7.27% with recovery rate of 2.381 cases (19.02%).[4] In Jakarta, the capital city of Indonesia, it was estimated that more than 100 hospital healthcare workers were infected with COVID-19.[5] Indonesian Medical Association released data of 25 doctors

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and 6 dentists who had passed away during this pandemic until May 8th 2020.[6]

SARS-Cov-19

Virology

Coronaviruses are categorized as enveloped virus. According to International Committee on Taxonomy of Viruses (ICTV), this virus is belongs to the realm of *Ribovirus*, *Nidovirales* order, in the family of *Coronaviridae and subfamily of ortho coronaviridae.* The subfamily of *orthocoronavirinae consists of four genera Alpha-, Beta-, Gamma- and Delta-coronavirus. SARS-CoV-2* belongs to genus *betacoronavirus* which usually infects mammals, and cause mild to severe respiratory syndrome.[3]

This virus possess a positive-sense single-stranded RNA (+ssRNA) and a nucleocapsid of helical symmetry.[3] The virus size is around 50-150 nm in diameter. Under the electron micrographs, the virus has 80 nm envelope in the middle and 20 nm club-shaped spike project from their surface. Its image resembles solar corona, from which the name obtained. Coronavirus genome size range is around 26-32 kilobases, and considered as one of the largest RNA viruses.[7]

The spike, a glycoprotein membrane developed by the enveloped virus, plays an important role in facilitating entrance into the host cells. Infection of host cells is begun by the binding of the spike and receptors on the cell's surface. Spike protein attaches to host cells and facilitate synthesis of the virus and the host membranes, thus permitting the inclusion of the genome into the host cell's cytoplasm.[5]

Transmission and mode of transmission

The SARS-CoV-2 as its antecessor is a zoonotic virus. It is closely related to the Chinese rufous horseshoe bat (*Rhinolophus sinicus*). At the beginning, it was suggested that the virus originated from the Huanan Seafood Market, Wuhan, China. And pangolin (*Manis javanica*) had been proposed as intermediary host. However, another research of phylo-epidemiologic analysis concluded that SARS-CoV-2 could have been imported from other places. Until today, the exact origin of this virus remains unknown.[5]

China's CDC revealed the incubation time of COVID-19 around 3 - 7 days and may last to 2 weeks. This data also showed that COVID-19 doubled about every 7 days. Preliminary study shows that the basic reproduction number (Ro) varies between 2.24-3.58. In other words, each patient, on average, may infects 2.2 more individuals. This reproduction number is much higher than seasonal influenza (Ro=1.27-1.80) and indicates that this virus is highly contagious.[8]

Most viruses will attach to the surface and recognize cell surface receptor of the host cell for invasion. Study had identified that the Angiotensin converting enzyme-2 (ACE-2) act as receptor for SARS-CoV-2, similar to its antecessor. The invasion was begun when spike protein create bond with ACE-2 receptor (Figure 1A). Then the complex was processed proteolytically by transmembrane protease type 2 (TMPRSS2). ACE-2 receptor was cleaved and the spike protein was activated (Figure 1B), and thus facilitating the entrance of virus into the target cell (Figure 1C).[9] This process is similar to the mechanism of human metapneumovirus and influenza.

This new virus shares the same host's receptor as the SARS-CoV-1 but in a higher affinity. Any cells expressing surface receptor ACE-2 are susceptible to SARS-COV-2. ACE2 was easily found expressed in lungs, arteries, esophagus, ileum, colon, and bladder.[10]

Several studies have also revealed oral cavity have ACE2 receptor. This receptor can be found on tongue and salivary gland, suggesting saliva may have a role in transmission of COVID-19.[9] According to current evidence, COVID-19 virus is primarily transmitted between people through respiratory droplets and contact routes. WHO announced that touching contaminated surfaces without washing hands may transmit the disease. Droplets, from coughing, sneezing or talking, generated by an infected people may also transmit SARS-CoV-2. Even very small droplets less than 5μm in diameter, referred as droplet nuclei, may transmit the disease.[10]

Airborne, the virus may be detected in the air for up to 3 hours and may be 4 meters away from the patient. Another research also found that the virus has high survival rate in low temperature. After 60 mins post aerosolization, the presence of living particle is more than 63% in 25°C. The presence of living particle is reduced significantly to 4.7% in 38°C. This data suggests that SARS CoV may have potential occupational hazard to health and dental workers.[11]

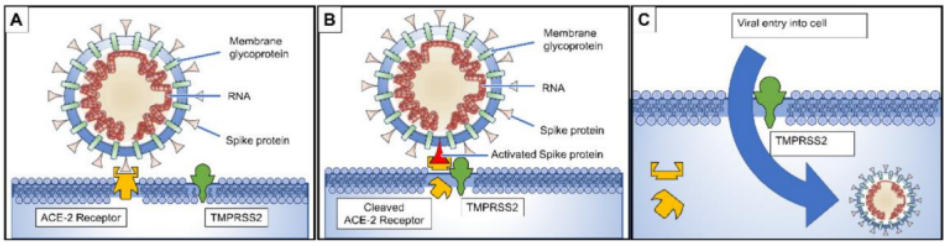

Figure 1. Host cell recognition and invasion.[9]

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Clinical findings of COVID-19

The symptoms of this disease vary from asymptomatic, presymptomatic to respiratory failure that requires ventilator.[12] COVID-19 may also lead to septic shock, sepsis, and multiple organ dysfunction syndromes (MODS).[13] Clinical manifestations of this disease may be best described by its severity: Mild disease: occurred in 81% cases of non-pneumonia and mild pneumonia. Only mild to moderate respiratory disturbances and may recover without any special medical treatment; Severe disease: occurred in 14% of cases. Characterized with dyspnea, respiratory frequency less than 30x/min, oxygen saturation (SpO2) less than 93%, Horowitz index (P/F ratio) less than 300, or the presence of lung infiltrates more than 50% within 24 to 48 hours; Critical disease: occurred in 5% of all cases, and characterized by respiratory failure, septic shock, or the presence of multiple organ dysfunction syndrome (MODS).

Computerized tomography (CT) scans of confirmed COVID-19 pneumonia demonstrated a various pattern with affect both the interstitium and lung parenchyma.[12] Most typical finding is airspace opacities, or commonly described as consolidation or ground glass opacity (GGO) or mixed GGO. Lesions, the ground-glass or consolidative opacity, tend to have bilateral, peripheral, basal predominant distribution and multifocal.[13]

Nosocomial infection in dental practice

In the current time, when the COVID-19 outbreak has become more serious, the most recommended guidelines are: Dentists should limit the procedures in their practice, and reduce the number of dental appointments. During the COVID-19 pandemic, some protocols i.e physical distancing, limit interpersonal contact and reduce patient's queue on the waiting room, shall be applied to the dental care. Dentist are recommended to use personal protective equipment level 3 while performing emergency treatment. It is also recommended to postpone all elective care for unspecified time.[14]

Impact on dental practice

Significant impact of COVID-19 that has been reported includes the decrease in the number of patients, where only 38% patients visited the dental clinic during the COVID-19 pandemic. The cases were dominated by dental trauma and oral infection. The other report suggested that the regular visit reduced by five percent during the pandemic which in turn bring some financial impact on dental practices around the world.[14]

DISCUSSION

In dental practice, the most common splatter will be on nose and inner eyes.[15] The Indonesian Dental Association had proposed a special issue for PPEs which include proper donning and doffing, and also hand washing technique, corresponding to WHO.[14] Even though no protective measure is guaranteed, we believe that we have to do extra precautions to prevent self and cross- contamination.

Until today, guidelines for dental practice re-opening is limited. We would like to review all recommendation to provide specific guidelines to dental practice in Indonesia. Indonesia may have a little difference with the other country. It has tropical climate, average daily temperature is hot with relatively high humidity. We divided this section into: Personal Protective Equipment (PPEs) and hand hygiene, protect dentist, dental team, and patients as well; Patient selection to reduce possibility of positive COVID-19 transmission during dental treatment; Aerosol reduction, when the use of AGPs is inevitable, we have to be able to reduce the viral load and aerosol spread across the room; and room disinfection, after the treatment, we have to avoid cross-contamination to the next patient.[16,17]

There are some Personal Protective Equipment (PPEs) for dental practice, such as Filtering face piece PPE : Surgical mask or N95 respirator, face shield, protectives goggles and hand hygiene. First PPEs is Filtering facepiece PPE: Surgical mask or N95 respirator. The most common filtering facepiece utilized by health care workers are N95 respirator or facemask (sometimes called surgical mask). These filtering facepiece is parts of protective personal equipment to protect the healthcare workers from inhaling contaminated airborne particle. These devices are disposable and worn on the face, covering the nose and mouth.[17] Numerous studies had been conducted in order to test the efficacy between surgical mask and N95 respirator in protecting the wearer especially from viral infection.[18]

Even though N95 respirator offers high protection, this kind of respirator may inhibit air exchange and thus increase additional metabolic workload.[17] Dentists should be warned of negative effect in the protracted use of N95, which may cause discomfort, shortness of air due to the increase in breathing resistance, and CO2 level. Some wearers also complain of headache, lightheadedness, and difficulty communicating.[19] Research had confirmed that such changes minimally affect physical work performances.[20]

Second PPEs is face shield. The efficacy of face shield in reducing the aerosol exposure to the wearer's had been proposed and tested in various condition. Some studies had been conducted to test the efficacy of face shield in order to reduce the expelled aerosols and splatter of body fluids.[21] Splash and splatter from surgical procedures may result from the use of various high speed drills. The incidence is quite high, despite being not in a dental setting.[22]

The third PPEs that is used by dental practice is protective goggles. The use of protective goggles is mandatory. Previous study had indicated that SARS-CoV-2 may be present in tears. Despite being low in incidence, however, the virus may have a second route of transmission via conjunctiva. Therefore, protective goggles, is mandatory.[23–25]

Besides that, hand hygiene is important for dental practice. WHO always recommended to wash hand in

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healthcare facilities. The procedure of hand hygiene had been widely spread. Use clean and running water for hand hygiene. Use and apply the enough amount of soap to cover all surfaces. It is estimated that 40-60 seconds is enough to clean all surfaces. The use of disposable towel is preferable.[26]

In patient evaluation, the most important thing is patient triage. The Indonesian Dental Association had proposed some guidelines for the treatment that shall be done during the pandemic. It is also suggested to postpone elective treatment and do telemedicine. Telemedicine can be used for taking anamnesis, visual examination, make a diagnosis even for prescribe a medicine.[27]

Once you have determined that the patient is in need of urgent emergency care, then we have to screen the patient. Ask them via telephone or another telemedicine platform to take anamnesis. Some questions had been developed to pre-screen the patients: 1) Have you got any fever for the last 14 days?; 2) Have you experienced any breathing difficulties such as cough in the last 14 days?; 3) Have you, within 14 days, travelling in the red zone area of COVID-19 as stated by Indonesian government?; 4) Have you, within 14 days, get in touch to person with fever, or cough or breathing difficulties or person shall be suspected with COVID-19?; 5) Have you participated in any social gathering or meeting and got in touch with many unacquainted participants recently?

If a patient answer 'yes' for any question, advise them not to continue dental treatment, they should be self-quarantined, and referred to the nearest hospital or public health facility.[28] Dentist could only continue treatment if the patient answer 'no' for all question and the body temperature is below 37.3°C before entering clinic, otherwise, patient need to be referred to the nearest hospital or public health facility for further assessment. The use of non-contact forehead thermometer for thermal body screening is recommended before patient can enter the dental clinic.[28] Social distancing protocol, hand hygiene protocol for patient can be introduced to patient. Eye protector, and disposable gloves can also be dispensed to each patient before entering the clinic and start the treatment.

During the dental treatment it is imperative to reduce the aerosol exposure (Figure 2). Avoid the use of dental handpiece whenever possible. However, if AGPs cannot be avoided, it is required that we to reduce the infection risk from aerosol exposure.

Mouthwash, such as Hydrogen Peroxide 1.5% or Povidone Iodine 0.2% before treatment, had been proposed as effective protocol to reduce the viral and bacterial load on oral cavity, and in turn reduce the viral load on aerosol or splatter.[29–31]

Aerosol containment box: development of a containment box from acrylic or PVC pipe and wrap had been seen as an effort to prevent the aerosol spread. However, this type of box may hinder the operator sight and restrict hand movement which eventually limits the type of dental procedures that can be performed. The other innovation seen on social media is dentist tries to place a round plastic sheet with a hole for handpiece or scaler on the middle. Until today no study had been conducted to test its effectiveness in reducing aerosol spread.

Aerosol Suction and High Vacuum Evacuator: very few studies had been conducted regarding the use of central vacuum system found in PUBMED. Liu MH et al., reported that central vacuum system with 28.5 liter per minute is effective in reducing aerosol by 36%.[32] Vacuum system was reported more effective in reducing the aerosol exposure on dentist than the use of filtering respirator alone. Another study also emphasizes the use of high vacuum evacuator as it may reduce the ultrafine particle exposure on patient and dentists more than 80% compared to conventional dental suction. Some dentists also modify the vacuum cleaner unit to be an aerosol suction. UVGI requires time to kill the virus. The question still remains as the coronavirus size is 0.125 micron and HEPA filter is effective in capturing particle larger than 0.30 micron. Literature stated that it is 70% of 0.3-µm particles and 95% of 1.0-µm particles.[33] The result may be different, there are also other claims in which the efficiency of HEPA filter in capturing virus is less than 0.1 µm by means of electrostaticity.[33–35]

However, due to the lack of data supporting the use of HEPA in filtering coronavirus, we recommend to release

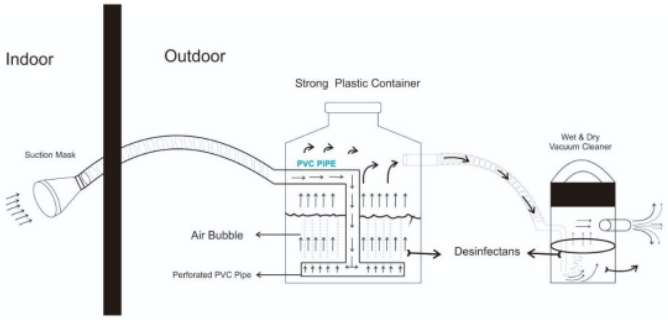

Figure 2. Example of modification on the concept of vacuum cleaner to reduce the aerosol. (Originally designed by Dr. AP. Hudyono).

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the output of the aerosol suction outside the room. The virus will be easily inactivated by the hot temperature and humidity outside.[36]

The routine use of rubber dam on root canal treatment and restoration can reduce the amount of saliva splashes that will become droplets. We can disinfect cavities and reduce the amount of virus in the distribution of droplets use rubber dam. Rubber dam can lessen the spread of microorganisms significantly (90-98%).[37]

Some chemicals are known to have the ability to remove caries tissue without using a bur. The main principle of chemo-mechanical caries removal (CMCR). Instead of drilling, this technique works by chemically softening the caries tissue so that caries can be easily cleaned using a hand instrument. CMCR can now be classified into sodium hypochlorite-based agents (NaOCl) or enzyme-based agents.[38,39]

Indonesia has tropical climate with hot temperature in daily average. A room conditioner is highly required in every dental practice. However, this appliance may complicate the room disinfection and may facilitate the virus spread across the room. For room disinfection we should prepare the condition, such as air ventilation, ozone and hydroxyl agents and cleaning on floor and surfaces of dental unit.

The importance of air ventilated room in dental clinic is well described in some studies. It was known that dental clinic is associated with various pollutants, pathogenic microbes, chemical or ultrafine particles. A study found that a high level of CO2, total VOCs and Particulate Matter were found during the operational hours, and were reduced significantly in close hour.[40]

The ventilation rate is measured as air change per hour (ACH, sometimes abbreviated as ACPH). It is a measure of how much air volume is changed, either added or removed, from a room in an hour[41]. Generally said this is to measure of how many times the air in a room is replaced. In order to achieve equilibrium pressure, the amount of air leaving and entering the space must be the same. The ACH is measured by dividing air flow changes in a room for an hour with the volume of the room itself. The ACH is simply counted by equation below:

$$\mathrm{ACH} = \frac{60\ \mathrm{Q}}{\mathrm{P} \times \mathrm{L} \times \mathrm{T} \times \mathrm{c}}$$

Where:
ACH = air change rate per hour
Q = air flow per minute in cubic feet per minute (cfm) or liter per minute or meter cubic/minute
PxLxT = room dimension in meter
c = conversion value (if Q is in liter per minute, c is 1000; If Q is in cubic feet (cfm), c is 35,29; if Q is in meter cubic per minute, then c is 1)

The air change rate is not the only factor. The design of ventilation system, flow pathways, and its distance from contaminant source shall be considered to be more important than ACH number or flow rate itself.[40,41] Consideration of contaminant source suggests the importance of aerosol suction for the first line to remove the contaminant from the air.

UV is an electromagnetic radiation with short wavelengths. It is shorter than visible light but longer than X-rays. Corresponding to its wavelength, UV is divided into three categories, UVA, UVB, and UVC, and the germicidal effect is only seen in UVC. Natural UVC is present in very little amount as the ozone layer blocked it. However, the UV-C can be artificially generated by some method, i.e mercury-based lamps, light emitting diode, or pulse xenon.

The germicidal effect of UV-C is achieved by damaging the nucleic acid of microbes. Wavelengths between about 200 nm and 300 nm are strongly absorbed by nucleic acids. The principal mode of inactivation occurs when the absorption of a photon forms pyrimidine dimers between adjacent thymine bases and renders the microbe incapable of replicating.

UVGI is mainly used today to disinfect water, air, and surfaces. The surfaces disinfection is limited due to shadows or protective layer. The UVGI had been widely used for water and air sterilization. The UVGI is also employed in many industrial lines to help disinfection processes. Water disinfection is currently the most advanced and proven application. UVGI is also widely used for air disinfection. Several methods are available, including a full-room irradiation (when it is not occupied) or only the upper room, or irradiating air as it passes through enclosed air-circulation and heating, ventilation, and air-conditioning (HVAC) systems.[42] The susceptibility of SARS-CoV-2 to UVGI has not been documented yet. However, UVGI effect had been studied to previously known coronavirus, included the SARS-CoV-1 and MERS-CoV.

Even though the use of UVGI is effective in laboratory, the case may be different in clinical setting. The UVGI effectivity is mainly affected by distance from the UV light source, and the presence of obstacles in the room may prevent the UV light to reach the target.[42] We found that some data which state that the UVGI is partially effective in inactivating coronavirus for dental practice.

Ozone, a trioxygen, is a chemical compound with symbol O_3. It is considered to be very reactive to organic compounds. Ozone is regarded as a promising method to inactivate viruses. When ozone breaks down to dioxygen, it produces free radicals of oxygen which is very damaging to organic compounds. Virus inactivation by ozone is influenced by ozone concentration, contact time, different capsid architecture of viruses, and relative humidity (RH). The authors observed that the survival fraction of viruses on surfaces decreased with the increasing ozone dose.

The ozone dose is stated by min (mg/m^3) which means contact time (in minutes) multiplied by ozone concentration (in mg/m^3). Viruses required ozone doses of 20-112 min

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(mg/m^3) for 90% inactivation and 47-223 min (mg/m^3) for 99% inactivation. The ozone dose for 99% inactivation is two times higher than for 90% inactivation. The ozone generator usually produces 500 mg/m^3 in a minute (depends on the manufacturer). For a room 3 x 3 x 2.5 meters, it can be calculated that 10-15 minutes is required to inactivate coronavirus in a room.

The low relative humidity may increase the ozone concentration required for virus inactivation. In summary, ozone should be an effective method for reducing the viral number on surfaces.[43] Another study also found that low ozone exposure may be beneficial in inactivation of enveloped virus. Concentration of 1.13 ppm ± 0.26 ppm was enough to yield the same result.[44]

The Occupational Safety and Health Administration (OSHA) in USA, has set a Public Health Air Standards limit for ozone exposure as much as 0.1 ppm for 8 h or 0.3 ppm for 15 min. Using appropriate generators at appropriate ozone concentrations, ozone will help to decontaminate rooms, hospital room, public transport, etc. Ozone is toxic when inhaled, therefore, room decontamination must be free of people and animals.[45]

Cleaning shall be done following the room disinfection, before new patient enters the room. The rationale is, the longer the period, the aerosol and splatter will come on the floor by gravitation, and the viral count on the ambient air will be reduced by means of UVGI, or ozone, and exhaust fan. This arrangement may prevent the cleaning staff from being exposed to aerosol, and the cleaning will be more effective as the aerosol and splatter has fallen to the floor and the dental unit. CDC recommends to use damp soft mop to clean floor surfaces and damp microfiber cloth for all surfaces of dental unit.[44] We found that cleaning is a beneficial and may provide a clean environment.

Rapid change in guidelines for dental practice reopening may occur based on recent research on COVID-19 and the situation in the community. For the concluding remarks, until today no protection method has been proven against SARS-CoV-2. No single protocol may guarantee the prevention of cross or self-contamination. We find that the use of PPEs and patient triage is mandatory in reducing the risk of infection. Air ventilation rate, control on the aerosol spread, and disinfection of floor and dental unit surface are beneficial in reducing the contaminant in room.

However, the use of air conditioned has not been resolved. Until today, there is no protocol that can be used to sterilize the air conditioner in dental practice facility. Ozone may be promising, but it needs to be researched further. We recommended to limit the use of air conditioner unit as little as possible. Or place an air conditioner unit in the waiting room, and let the cool air enter the room by means of negative pressure from exhaust fan. Overall, can be concluded that no single protocol may fully guarantee the safety of the patients and dental workers. We strongly suggest to combine the protocol listed above to minimize to self and cross-contamination.

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