Preventive and Control Measures for the Coronavirus Pandemic in Clinical Dentistry

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A severe public health crisis has been declared worldwide since coronavirus disease 2019 (COVID-19) was classified as a pandemic of acute respiratory infectious disease by the World Health Organisation (WHO). China has taken strict measures to curb the spread of the disease to save lives, and has managed to control the outbreak. COVID-19 is mainly transmitted through respiratory droplets and close physical contact, so it is challenging to prevent nosocomial infection and possible spread during dental treatment. Since the initial phase of the COVID-19 outbreak, a disease prevention and control strategy based on the new concept of population risk classification and rational use of personal protective equipment has been implemented by the Peking University Hospital of Stomatology. Nosocomial infection prevention and control concepts and measures relating to dental diagnosis and treatment are critically checked in the hospital. Our experiences in handling this situation are shared here and may have wide-ranging implications for infection prevention and control (IPC) for COVID-19 in dental practices worldwide.

Key words: *coronavirus disease 2019, dentistry, health care personnel, infection prevention and control, personal protective equipment, population risk classification*

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The coronavirus disease 2019 (COVID-19) pandemic poses a huge challenge to global public health. As of 8:43 am CEST on 24 May 2020, 84,525 COVID-19 cases in China and 5,080,956 cases in other countries and areas outside China have been reported to the World Health Organisation (WHO). The major source of new COVID-19 cases are patients diagnosed with SARS-CoV-2. However, patients with latent or asymptomatic infection are also an important source of new cases[1]. It is currently confirmed that COVID-19 is mainly transmitted between people through respiratory droplets and close physical contact[2]. There is a high risk of aerosol transmission in relatively enclosed spaces, particularly upon exposure to high concentrations of aerosol particles for prolonged periods[3]. In the case of COVID-19, most people of all ages have no immunity against SARS-CoV-2 and hence are generally susceptible to infection.

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Potential hazards to dental health care personnel

During treatment, dental health care personnel (DHCP) are in close proximity to patients, and there is often close physical contact between doctors and patients. The spray generated by dental treatment, containing saliva, blood and organic particles, readily causes air and environmental pollution in the clinic. Zhou et al[4] indicated that angiotensin-converting enzyme II (ACE2) is likely the cell receptor of SARS-CoV-2. Other researchers indi-

cated that those organs with high expression of ACE2 (e.g. respiratory system and oral mucosa) are highly susceptible to SARS-CoV-2 infection, particularly when the mouth is wide open during dental treatment[5,6]. He et al[7] observed the highest viral load in throat swabs at the onset of symptoms, and inferred that transmission peaked at or before this point. To et al[8] found that the viral load profile of SARS-CoV-2 in posterior oropharyngeal saliva was similar to that of influenza. Chen et al[9] also found positive detection of SARS-CoV-2 nucleic acid in the pure saliva of COVID-19 patients collected from the orifices of the salivary gland canal. All these findings demonstrated that infected people who already have high viral loads in the throat, saliva and oral cavity may only display mild symptoms or have not yet developed symptoms, but can readily produce aerosols containing infectious agents during dental treatment.

China's experience in preventing SARS-CoV-2 transmission in dental clinics and hospitals

Population risk classification

In China, where COVID-19 was an epidemic, public dental hospitals were reserved for the diagnosis and treatment of patients with acute or severe oral diseases as a preventive measure to safeguard the health of DHCP and other patients. However, as the epidemic was gradually being brought under control, public dental hospitals adopted a new concept of classified prevention and control based on different risk classifications of the population, and have successively resumed oral clinical services.

In accordance with the population risk classification, the population is divided into three groups based on current health status and epidemiological data, such as recent travel history, residence history and close contact history with COVID-19 patients. The risk grades are classified as:

1. High-risk individuals, who are from COVID-19 epidemic areas, who are suspected/confirmed COVID-19 patients, or who are in close contact with COVID-19/asymptomatic infected patients undergoing isolation and medical observation.
2. Medium-risk individuals, who are from COVID-19 outbreak areas, who are exhibiting fever, dry cough, shortness of breath and respiratory symptoms, or who are recovered COVID-19/asymptomatic infected patients who have been released from medical quarantine less than 14 days prior.
3. Low-risk individuals, who are from areas with few reported cases of COVID-19, and other individuals who are not classified as high-risk or medium-risk.

This population risk classification provides the basis for strict early screening and identification of suspected or confirmed cases in hospitals (Fig 1). Based on standard precautions and exposure risks of different dental procedures, DHCP need to take different levels of protective measures.

Rational and appropriate use of personal protective equipment for SARS-CoV-2

Because of the high usage and short supply of personal protective equipment (PPE) during epidemic prevention and control, the reasonable and appropriate use of PPE is a fundamental challenge. Classified protective measures can not only help DHCP to select the appropriate PPE in a standardised and systematic manner, but also enable more efficient use of PPE. Firstly, we arranged for the medical staff to work at the hospital in shifts, with most of them staying at home. Secondly, we classified and regulated the use of PPE after thoroughly evaluating and assessing the risks of occupational exposure of medical staff to COVID-19 (Table 1). High-risk patients usually need to be referred to designated hospitals where COVID-19 patients are admitted. However, if these high-risk patients are suffering from critical oral diseases that need urgent treatment, it is necessary to follow the principle of third-level protection, regardless of dental treatment procedures. For medium-risk patients, dental treatments can only be carried out if the patients display no symptoms of infectious disease (such as fever, dry cough and other respiratory symptoms, but which have not yet been confirmed to be COVID-19), or after the 14-day isolation/observation period. If it is necessary to deal with critical dental emergencies for medium-risk patients, DHCP should take second-level protective measures and wear medical protective face masks. For low-risk patients, the level of protection is appropriately reduced, and second-level protection can be selected for procedures that produce splatter or aerosols, or first-level protection for procedures where this is not a risk. One of the second-level protective measures for DHCP treating low-risk patients is different to that with medium-risk patients. When treating medium-risk patients with procedures that produce splatter or aerosols, DHCP should wear particulate respirators. Thirdly, we also utilised different types of gowns in different situations. We selected reusable non–fluid-resistant fabric gowns for proce-

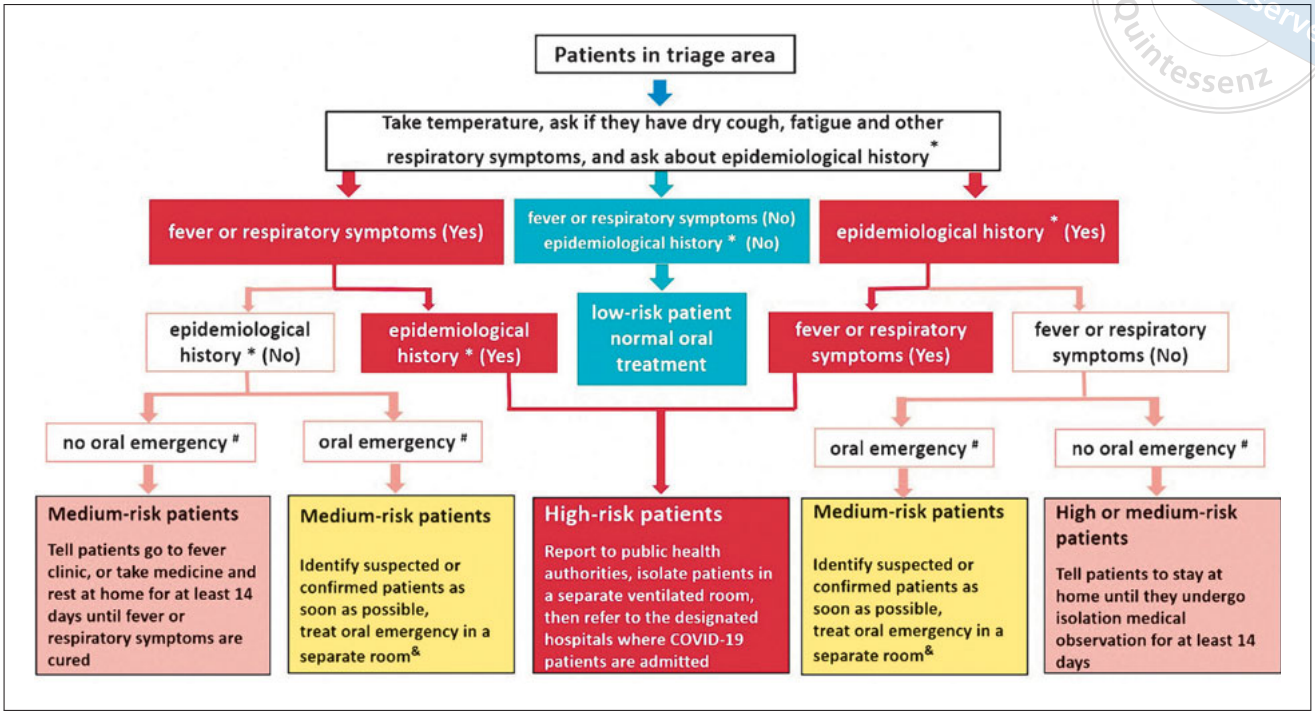

Fig 1 Decision tree for early screening and identification of suspected or confirmed COVID-19 cases at dental hospitals. *, Epidemiological history: recent travel history to COVID-19 epidemic or endemic areas, suspected/confirmed SARS-CoV-2 patient, or having had close contact with asymptomatic infected/COVID-19 patients who have been undergoing isolation/medical observation for less than 14 days; #, Oral emergency: patients with oral and maxillofacial trauma, acute pulpitis, oral maxillofacial cellulitis, etc.; &, Identifying suspected or confirmed patients through computed tomography of the chest and blood leukocyte/lymphocyte count, or SARS-CoV-2 nucleic acid test.

dures that did not produce splatter or aerosols (Fig 2) and single-use long-sleeved fluid-resistant gowns for procedures that did produce splatter or aerosols (Fig 3). Fourthly, we also improvised a fabric dickey to protect DHCP's necks from splashes of blood, body fluid and secretions, in order to reduce usage of single-use PPE (Figs 2 and 3).

Infection prevention and control bundle measures for aerosol-generating dental procedures

Besides the concept of PPE ranking, for non–high-risk patients who require urgent aerosol-generating dental treatment, we have formulated infection prevention and

Table 1 PPE hierarchy for DHCP during COVID-19 outbreak or epidemic period.

Risk classification	Procedure category	PPE hierarchy	PPE
Low-risk patients	Procedures without splatter or aerosols	First level (standard precaution)	Hair covers, surgical masks, work clothes, single-use gloves
Low-risk patients	Procedures with splatter or aerosols	Second level (advanced protection)	Hair covers, surgical masks or particulate respirators (at least as protective as a NIOSH-certified N95 or equivalent), medical masks and eye protection (face shields or goggles), work clothes, gowns, single-use gloves
Medium-risk patients	All procedures		
High-risk patients	All procedures	Third level (strengthened protection)	Hair covers, particulate respirators (at least as protective as a NIOSH-certified N95 or equivalent), eye protection (face shields or goggles), work clothes, medical protective clothing, single-use gloves, medical isolation shoe covers (cleaning and equipment disinfection staff can wear plastic aprons/gowns, reusable long-sleeved vinyl or rubber gloves in addition, if necessary)

Fig 2 PPE for operations without splatter or aerosols in second-level protection, and reusable non–fluid-resistant fabric gowns and dickeys (left).

Fig 3 PPE for operations with splatter or aerosols in second-level protection, and single-use long-sleeved fluid-resistant gowns (right).

control (IPC) bundle measures based on four aspects: engineering controls, diagnosis and treatment, personal protection and environmental disinfection. These measures include treating patients in a well-ventilated independent clinic, increasing the ventilation rate in the clinic, preparing patients before diagnosis and treatment and disinfecting the environment after treatment (Table 2).

Suggested precautionary measures for DHCP in other countries

Based on the implementation of the above measures, we propose some measures to safeguard DHCP in other countries during the fight against COVID-19. During the epidemic period, we should first classify the risk of different segments of the population, strengthen procedures for early screening and identification of patients, and clearly specify the implementation of standard precautionary and additional preventive measures. Secondly, the personal protection of DHCP is based on the principles of standard precautions. Based on the transmission route, for example physical contact, droplets and airborne transmission, various precautionary measures are established. Countries experiencing an outbreak of COVID-19 are advised to stop treating any patients not suffering from serious or severe oral diseases and to restrict treatment to patients with dental emergencies, and also strengthen management of the clinical environment and engineering controls. DHCP should adopt three levels of protection measures and view every patient as a potential carrier of infection. Additionally, PPE must be put on and removed correctly. Countries not experiencing a serious epidemic and with few COVID-19 cases may consider treating limited numbers of patients with non-acute dental problems, as well as patients needing emergency dental treatment. The number of DHCP should be reasonably matched with the number of patients. Dental clinics should also minimise the number of dental procedures likely to generate aerosols. The various aforementioned classified protective measures can be taken. Because COVID-19 is a sudden epidemic for each country, supplies for IPC have always been insufficient. PPE should be used rationally and appropriately based on the risk of exposure (e.g. population risk classification) and the transmission dynamics of SARS-CoV-2. Both population risk classification and use of PPE are flexible precautionary measures that can be adapted to other infectious diseases. It is also an effective and cost-efficient means of protection which is worth promoting. We also suggest shortening the treatment time for patients as much as possible at the onset of a disease outbreak and during the epidemic period. The assessment performed by Manarte-Monteiro et al[10] showed that the bacterial colony-forming unit (CFU) counts of aerosols were significantly higher at 0.5 m during endodontic treatments. van Doremalen et al[11]

Table 2 IPC bundle measures for aerosol-generating dental procedures.

In preparation for patient treatment	
Layout of treatment room	Use adequately ventilated rooms with a window
Air conditioning ventilation system	The maximum fresh air volume should be ensured from the central air conditioning system. The return air vent of the central air conditioning system should be closed and the window should be opened, calculating that there would be about 10 air changes per hour (ACH) and > 100l/s/patient (hourly average ventilation rate), which can provide a higher dilution capacity
People management	Limit the number of people entering the room; if possible, "one patient, per room"
Wearing of PPE	Work clothes, hair covers, particulate respirators, medical masks and eye protection (face shields or goggles), disposable gowns, single-use gloves
During patient treatment	
Oral preparation	Use 3% Hydrogen peroxide to gargle
	Use rubber dam
	Use strong suction device
People management	Reduce opening and closing of doors, limit number of people walking around
After patient treatment	
Remove PPE	Prevents self-contamination or self-inoculation with contaminated PPE or hands
Object surfaces	Pre-clean first, then disinfect with sodium hypochlorite
Equipment surfaces	Pre-clean first, then disinfect with 75% alcohol
Air	Use ultraviolet germicidal irradiation (UVGI) for disinfection of air for 30 min

recently found that COVID-19 was detectable for up to three hours in aerosols, up to four hours on copper surfaces, and up to 24 hours on cardboard surfaces. These two independent studies demonstrated that both bacterial and viral particles in aerosols may cause disease transmission during routine dental treatment procedures. Therefore, DHCP should practise strict hand hygiene and proper environmental management to prevent transmission through contact.

What can we learn for the prevention and control of COVID-19 and other epidemics?

The WHO has announced that COVID-19 can be characterised as a pandemic[12]. As of 2 May 2020, Beijing has a total of 419 locally confirmed COVID-19 cases and 174 imported cases. Since the outbreak began, a total of 66,626 outpatients and 504 inpatients have been treated in our hospital (from 1 February to 23 May 2020). So far, there has been no report of either DHCP or patients being infected with SARS-CoV-2 due to dental treatment in our hospital, which means that the personnel risk classification measures and rational use of PPE are proving effective. In addition, special pathways for DHCP, patients and goods transportation have been planned and coordinated to avoid gatherings of people and keep a distance of at least one metre between individuals. The layout and procedures of the hospital rooms have been reorganised to ensure that a room is available for each patient.

There are four main routes by which infectious pathogens can be transmitted in clinical dental practice: transmission by direct contact, indirect contact such as touching a surface with contaminated hands, percutaneous (parenteral) transmission such as sharps injuries, and airborne transmission[13]. This is mainly a summary of our experience in preventing and controlling the spread of droplets and aerosols. Besides SARS-CoV-2, other organisms which may be transmitted in droplets/aerosols include mycobacterium tuberculosis and respiratory viruses, such as rhinoviruses, adenoviruses, and influenza viruses. Some of the herpesviruses such as varicella zoster virus (VZV) and Epstein-Barr virus (EBV) can also be transmitted by respiratory secretions. Patients with acute infectious diseases usually show obvious symptoms, but there are still some patients in the pre-infection stage who are infectious but do not display any clinical symptoms. Additionally, there are some patients in the convalescence phase of infection whose secretions are still infectious. Guan et al[14] analysed the data of 1,099 patients with laboratory-confirmed COVID-19 from 552 hospitals in 30 provinces, autonomous regions and municipalities in China up to 29 January 2020 and found that 43.8% of COVID-19 patients had a fever when admitted, but 88.7% of them developed a fever after admission.

Since we cannot effectively identify asymptomatic infections, standard precautions should be taken for all patients, but infections through airborne transmission may not be easily controlled by routine IPC measures. Therefore, for future dental diagnosis and treatment, it is necessary to strengthen procedures for comprehensive patient consultation, improve the understanding of patients' systemic diseases, utilise appropriate methods to ascertain patients' epidemiological history, and encourage them to actively share their history of infectious diseases, so as to achieve the objectives of early screening and identification of infected patients. At the same time, emergency treatments for such patients cannot be denied, especially for oral and maxillofacial surgery patients. Yang et al[15] established the diagnosis and treatment procedures for oral and maxillofacial surgery patients according to the urgency and severity of the disease and interventions. Rigorous protocols must be implemented to prepare the isolation treatment room, along with other measures to ensure high-quality diagnosis and treatment. Environmental and engineering controls should also be used to prevent the spread of infectious diseases. According to the characteristics of the patient's infectious disease, the risk classification of the patient's potential for disease transmission should be reasonably evaluated during diagnosis and treatment, and extra protective measures should be taken based on standard precautions. This study provides a new focus and direction for IPC within clinical dentistry globally.

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Conflicts of interest

The authors declare no conflicts of interest related to this study.

Author contribution

Drs Xiao Chi CHEN, Jian Fen DING and Dan Hui XU contributed to data acquisition, analysis and interpretation and drafting the manuscript; Drs Zhi Gang CAI, Xiu E LI and Zu Dong SHI contributed to data analysis, interpretation and critical revisions of the manuscript; Profs Chuan Bin GUO and Yong Sheng ZHOU contributed to conception and design of the study and critical revision of the manuscript. All authors gave their final approval and agreed to be accountable for all aspects of the work.

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