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Review article

Infection control in dentistry during COVID – 19 pandemic: what has changed?

Mrudula Patel *

Department of Clinical Microbiology and Infectious Diseases, School of Pathology, Faculty of Health Sciences, University of the Witwatersrand, and Infection Control Services, National Health Laboratory Services, Johannesburg, South Africa

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ABSTRACT

The novel coronavirus (COVID-19) pandemic has emerged disrupting many socio-economical and healthcare aspects across the world. This virus can be transmitted by symptomatic and asymptomatic individuals through saliva and contact. Due to its airborne transmission, aerosols created by natural activities and during dental treatment of infected individuals have become a potential vehicle of transmission and threat. The objective of this review was to assess the existing infection control measures taken in dental health-care settings and suggest modifications to reduce the transmission of novel coronavirus. This is a general review publication. Literature search was made at National Library of Medicine, Pubmed using key words such as "dentistry and COVID", "dentistry and COVID and infection control". Publications related to behaviour, education, ethics, treatment and childcare were excluded. Publications describing general aspects of infection control were reviewed. Keyword "Dentistry and COVID and Infection control" generated 70 publications which were reviewed. Infection control measures in dentistry are designed to minimise cross transmission mainly of blood borne pathogens. The unique nature of COVID-19 including highly infectious and transmissibility, and the ability to survive for a long time in the environment requires special attention and modification to the existing infection control measures which are highlighted here. In conclusion, a modified infection prevention and control (IPC) regime will protect the dental practitioner, assistant and staff, patients and the community. During the pandemic, drastic measures are necessary, however, during an endemic period measures can be remodified as necessary.

1. Introduction

Coronavirus disease 2019 also called COVID-19, although originated in China, within 3 months it spread to many countries becoming a WHO declared pandemic. It has caused worldwide major disruption in public health and in social aspects, as well as in the economy. It is an infectious respiratory disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Airborne transmission of the virus is the primary mode of transmission. Through sneezing, coughing and breathing, both symptomatic and asymptomatic patients can transmit this virus by contaminating the air around them. Uncovered cough can expel droplets up to 4 m [1]. Droplets and aerosols created by these infected individuals are inhaled by uninfected individuals. Experimental research has shown that SARS-CoV-2 can survive in aerosols [2, 3]. In addition, virus containing droplets and aerosols eventually settle down due to gravity, contaminating surfaces where the virus can survive for a long time. It is known that in favourable conditions, SARS-CoV-2 virus can survive on surfaces such as plastic and stainless steel (7 days), treated wood and cloth (2 days) cardboard (24 h) and the outer layer of surgical masks for up to 7 days [4]. This makes these surfaces a potential vehicle for virus transmission through contact, and it stresses the importance of hand hygiene.

This is a general review covering infection control aspects in dentistry during the COVID pandemic. A literature search was made at National Library of Medicine, Pubmed.gov using key words such as "dentistry and COVID" (357 publications), "dentistry and COVID and infection control" (70 publications). Publications related to behaviour, education, ethics, treatment and childcare were excluded. Publications describing general aspects of infection control were reviewed.

2. Role of saliva in the COVID-19 transmission

Saliva is an important source of transmission due to aerosols created through natural activities such as breathing, sneezing and coughing,

* Corresponding author.
E-mail address: mrudula.patel@wits.ac.za.

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posing potential danger to healthy uninfected individuals as well as healthcare workers in medical facilities. However, dental personnel who work in close proximity to the oral cavity are at a greater risk due to the extensive aerosols created during dental treatment particularly during the use of high speed drills, ultrasonic scalers and air/water syringes.

SARS-CoV-2 virus has been detected in saliva samples of 87–100% of clinical patients [5, 6, 7]. Moreover, in a study on COVID-19 positive patients, it was shown that posterior oropharyngeal saliva samples were serially positive for viral load from the onset of symptoms to 25 days, whereas the serum samples were positive only for 14 days [7]. There are three pathways for SARS-CoV-2 to be present in saliva: the direct exchange of secretions from the upper and lower respiratory tract, and the oral cavity. The latter is the first and most important pathway. Gingival crevicular fluid present in the gingival crevice is rich with blood components and can also add viruses to the saliva. Lastly, major and minor salivary glands can be a source of this virus [8] because epithelial cells of salivary gland ducts are found to be an early target for SARS-CoV infections [9] through Angiotensin-converting enzyme 2 (ACE2) receptors, and the newly identified SARS-CoV-2 uses the same receptor to invade cells [10].

3. Infection control in dentistry

Following infection control principles and measures is a moral obligation of all healthcare workers. Dentistry is no exception. Infection control is important in dentistry because patient saliva may be contaminated with oral commensals and opportunistic pathogens. In addition, it can harbour specific pathogens during infection as well as during the carrier state, including SARS-CoV-2. Due to the nature of the dental procedures, exposure to the blood and saliva aerosols is unavoidable. Direct contact with fluid contaminated environmental surfaces, instruments and equipment are also a potential source of pathogen transmission. In a dental practice the dentist, dental assistant, instrument processing and administration staff, as well as the patients are at risk of transmission of infections. Dental laboratory staff members are also at risk due to the cross contamination between the clinic and the laboratory. In addition, it can be extended to their families if the infection control measures are not taken correctly. Therefore, historically step by step infection control measures have been recommended by the CDC and countries across the globe have drawn up individual country specific guidelines [11]. These infection control measures were drawn up with the understanding of the chain of infection and cross contamination. Infection control measures can be grouped into 6 categories as shown in Figure 1. These standard precautions, previously called universal precautions, covered all the aspects of infection control required in dental settings and they will not be discussed here.

What has changed in the infection control in dental practice during the present pandemic? Little if any research is available regarding transmission of COVID-19 in a dental setting. However, past literature of possible transmission of infections in dental settings, the known route of transmission and pathogenesis of COVID-19, the highly infectious nature of the causative virus and perhaps the requirement of low infectious dose, suggest the urgent need for modification of infection control measures. In addition, pre- and post-symptomatic and completely asymptomatic carriers can transmit the causative virus. He et al., (2020) has shown that viral shedding may begin 5–6 days before the appearance of the first symptoms. Presymptomatic carriers are difficult to identify. Although the viral load is shown to be the highest at the time of symptom onset, the infectiousness of the virus peaks on or before symptom onset [12]. Therefore, any person who enters into the surgery may be a potential source of transmission. The infection control regime can be modified for the current pandemic and thereafter for the long term endemic era. Many countries have banned or restricted dental procedures allowing only the minimum emergency treatment. This is not economical and not a long term solution. Therefore, if the dental practices are allowed to operate, until the vaccine is available, drastic infection control measures are required to prevent the transmission of COVID-19. Thereafter during the endemic period the standard precautions can be applied.

4. Patient history – past and present

Generally the history of a patient is taken just before examination. During the present pandemic the urgency of dental treatment should be determined before booking the patient. Before the appointment, a general history should be taken telephonically, via e-mails or other internet-based systems [13]. A COVID-19 screening questionnaire including symptoms, contacts and travel history should be taken. If it provides any indication of presence or possible presence of SARS-CoV-2 and the patient requires urgent treatment, extra infection control measures should be taken. During the peak epidemic period, non-emergency procedures should be postponed. If an appointment is made, the patient should be requested to come alone and wear a mask. If a patient requires assistance, only one person should be allowed while also wearing a mask and with a completed COVID-19 questionnaire.

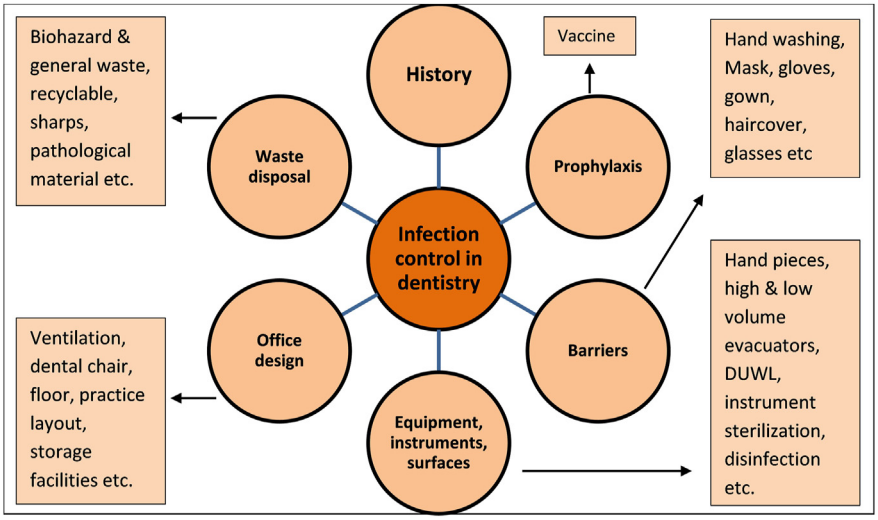

Figure 1. Aspects to consider during infection control in dentistry.

5. Preparation for treatment, administration and waiting area

Minimum and absolutely essential items should be left open and exposed. Toys and magazines should be removed. The administration and patient waiting area should be separated with a glass or plastic panel. A minimum number of chairs must be placed 6 feet apart either in the corridor or in the waiting area. Hand sanitisers containing ≥70% alcohol or other approved substance should be available for the patient and the accompanying person. Patients should be booked for 30 min longer than the required treatment time to allow step by step precautionary measures to take place and to minimise the number of waiting individuals and patients. Minimum administration staff with mask, social distancing and hand hygiene should be allowed and if it is not possible due to space constraints, staff should be rostered for working hours without an overlap. Transfer of patient records and related administrative material from the treatment area to the administration area should be avoided. Apart from the screening questionnaire, temperatures should be taken for all the individuals entering the practice using a contact free laser thermometer.

Mouth rinses containing antimicrobial compounds are commonly used for general oral hygiene and therapy. Among these antimicrobial compounds, the most commonly used are chlorhexidine, fluoride, triclosan, cetylpyridinium chloride, essential oils and iodine. The use of a therapeutic antimicrobial mouth rinse prior to the dental treatment can reduce aerosol contamination. It has been shown that cetylpyridinium chloride with or without domiphen bromide can reduce the bacterial burden by 57% [14, 15]. Although chlorhexidine with antibacterial and antifungal properties have been effectively used in dentistry, according to the Guidelines for the Diagnosis and Treatment of Corona virus pneumonia (5th edition) of the National Health Commission of the Republic of China, it may not be significantly effective against SARS-CoV-2 [16]. Kampf et al. [17], also showed that chlorhexidine was less effective against Corona viruses, however they investigated the efficacy at 0.02%. Nevertheless up to 0.2% can be used on the mucous membrane in the form of a mouth rinse. Therefore, further research should be done to explore the efficacy and possible use of 0.1–0.2% chlorhexidine mouth rinse before dental treatment.

Based on a surface disinfectant study on Corona viruses as a mouth rinse, the use of 0.5% hydrogen peroxide and 1% povidone iodine have been recommended [17, 18, 19]. Povidone iodine is generally used in the maintenance of oral health and in the prevention and treatment of oral infections as it is safe to use [20]. Although hydrogen peroxide is a known carcinogen, it has been used in cosmetic products as a beaching agent and in mouth rinses. At low concentrations used occasionally it has beneficial effects [21, 22]. In a study on patients admitted to the intensive care unit, 3% hydrogen peroxide mouth rinse reduced the rate of ventilator-associated pneumonia [21]. Carrouel et al, [23] have proposed the use of β-cyclodextrin together with a flavone, Citrox, to reduce the carriage of this virus. However, it requires further research to establish its efficacy. Since no data are currently available, use of any antimicrobial mouth rinse may reduce the number of microorganisms including SARS-CoV-2. During this pandemic period, patients should be advised to brush their teeth and use antimicrobial mouth rinse before they appear for dental treatment. Alternatively mouth rinse can be provided by the practitioner prior to the treatment. Since 62–71% ethanol has been shown to be effective against Corona viruses within 1 min [17], perhaps oral gel containing ethanol can be developed and applied in the oral cavity prior to dental treatment. The concentration of ethanol might be higher for use in the oral cavity, since it will soon become diluted due to the water spray during treatment and cleared by high and low volume evacuators. Due to the organic nature of saliva some of the antimicrobials may not be effective. Alcohol might be a better option because it was found to be effective within 30 s in the presence of organic material such as serum [24, 25].

6. Barriers

Barriers and personal protective gear are even more important in the dental practice because of the nature of the treatment. The use of high speed hand pieces and the use of water and air create saliva and blood contaminated aerosol (<50 μM size particles) or splatter (>50 μM size particles) [26, 27]. This aerosol contaminates an area of up to a distance of 8 feet from the patient's oral cavity [28]. Figure 2 shows the spread of aerosol around the patient including the back of the dental chair. With a use of a simulation model, Veena et al. [29], have shown that during ultrasonic scaling, the aerosols can extend up to 4 feet from the back of the chair. They also showed that the operator and the assistant's head, chest, arms and face mask were heavily contaminated. Even the inside of

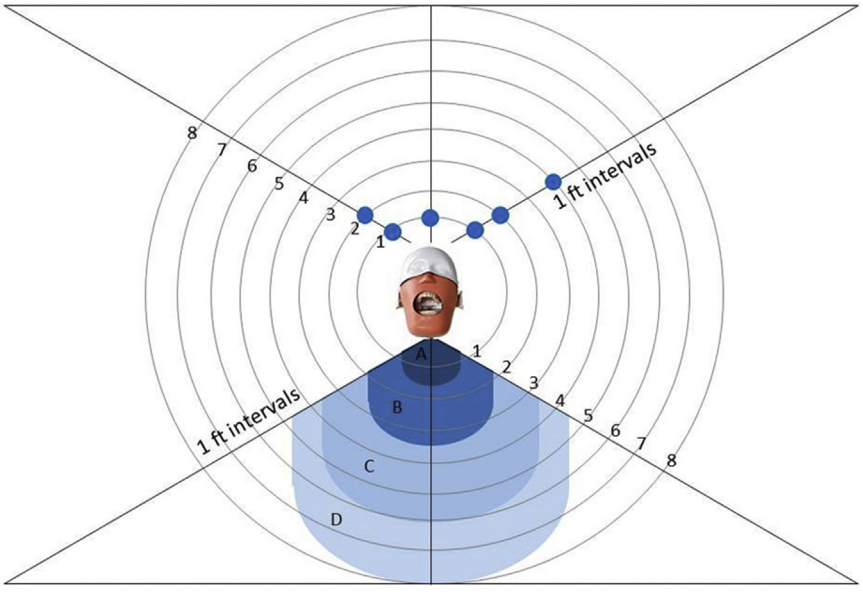

Figure 2. Spread of aerosol during dental procedures with the use of ultrasonic scaler and air/water spray. Where A: 10 000 colony forming unit (cfu)/ft^2, B: 1000 cfu/ft^2, C: 100 cfu/ft^2 and D: 10 cfu/ft^2. Blue dots show the distance with the presence of aerosol (Modified from Miller et al., 1971 [27] and Veena et al., 2015 [28]).

the face masks were contaminated. Therefore, appropriate gloves, mask, protective gowns, eye and hair cover has to be used. N95 or surgical masks are generally recommended. Nevertheless, the fit of the mask, proper positioning of the mask, movement by the wearer, length of the facial hair and voice level while speaking, all affect the bacterial filtration [30]. Facial shields covering the forehead, eyes and mask should preferably be used. Hair should be short and covered with a disposable cover. For males, beard should be removed. Although before and after patient treatment in the dental practice, hand hygiene is a prerequisite during the COVID-19 outbreak, it must be enforced. It should be practiced before and after patient contact, before putting on and after removing personal protective equipment (PPE) including gloves. Hand hygiene after removing PPE is particularly important. Gowns must be high collared, long sleeved and long enough to cover street clothes. A disposable long sleeve high collar protective plastic apron can be used over the gown. Closed shoes must be worn. Aerosol settles down slowly contaminating surfaces and floor, therefore during this epidemic disposable shoe covers should be used.

Studies have shown that aerosol cloud remains around the dental chair for more than 30 min after scaling [29, 31], therefore the protective barriers should not be removed immediately after the procedure.

In the treatment area only essential items and instruments should be exposed. The dental chair should be covered with thick plastic that can be disinfected before and after patient treatment. Spray and wipe technique should be used for the disinfection of all the exposed areas including chair, surfaces, light and handles. Dental prostheses, impressions and other prosthodontic materials should be disinfected before receiving and sending them to the dental laboratory.

According to CDC recommendation patient-care items (dental instruments, devices and equipment) are categorised as critical, semi-critical and non-critical. Semi-critical and critical items should be sterilised as most items are heat-tolerant. Heat-sensitive items should be processed with high-level disinfectant or sterilant. During the pandemic aerosol generating procedures should be avoided if at all possible, bearing in mind that economic effect may be punitive. If not then as many procedures as possible should be carried out under rubber dam. Figure 2 shows the extent of contamination during high speed procedures. Therefore, hand pieces and air/water syringes preferably should not be used. Using hand instrument procedures such as the atraumatic restorative technique should be performed wherever possible and indicated [11, 32]. A large bore tip (8 mm diameter or more) can remove air at the rate of 100 cubic feet per minute reducing aerosol and splatter by 93–96% [11, 33, 34]. Therefore, where possible during procedures high volume evacuators should be used.

Chlorine based disinfectants are known to act as high-level disinfectant and sterilants. Chlorine-based disinfectants have proved to be effective against Corona viruses [17]. They can be used on non-metal surfaces and floors, however care should be taken due to its corrosiveness. The effective concentration is 2000 mg/L which can be used to wipe high frequency contact surfaces. In addition, chlorinated solutions are not stable and therefore they have to be prepared fresh for use which has time and cost implications. Chlorinated compound such as Sodium dichloro isocyanurate is also beneficial because it is stable and proved to have antiviral effect [35]. Ethyl alcohol (70%) can also be used which is relatively inert and evaporates rapidly leaving surfaces dry. Benzalkonium chloride with or without Isopropyl alcohol has also shown antibacterial and antiviral properties [17, 36]. Slow release solution-based chlorine dioxide which has shown to have multipurpose use in dentistry should be further explored [37, 38]. It can be used as a surface disinfectant and to disinfect impression material. It can also be used in the dental unit water line (DUWL) and as a mouth rinse [39, 40, 41, 42]. Some chlorine dioxide tablets contain anticorrosive compounds which can be of additional advantage particularly in dentistry where many instruments are made of metal. Diluted alcohol can last for a long time. Floors should be wiped with a disinfectant twice a day.

DUWLs are potential sources of microorganisms due to the development of microbial biofilms and intermittent release of microorganisms into the treatment water. Many DUWLs has an anti-retraction valve which prevents the suck-back effect where the contaminated water is sucked from the patient's oral cavity contaminating the DUWL system. Therefore, dental practitioners should evaluate the anti-retraction valve or have it installed. A different type of water is used in the DUWL depending on the type of dental chair and the system. Treatment water can be either potable municipal water or from a dental chair reservoir which can be filled with sterile or nonsterile distilled water or disinfectant. All DUWL should carry disinfectant, therefore dental chair units that do not have reservoirs and connect to municipal water supplies should be immediately converted to reservoirs into which potable disinfectants can be placed. Chlorinated disinfectants such as chlorine dioxide and hypochlorous acid should be considered which has shown efficacy in the DUWL disinfection. In addition several studies have recommended a weekly shock treatment of DUWLs using a high-level disinfectant.

Sterilizers should be inspected and the efficacy should be determined using conventional biological, chemical and mechanical indicators [11].

7. Office design and ventilation

The success of an effective infection control program depends on proper office design. Floor plan, traffic flow, fixtures, dental chair, instrument processing and the recirculation area should be considered. The requirements are described in the 2003 CDC guidelines for infection control in dental settings. During the COVID-19 pandemic, it is not economical to refurbish the practice but some modifications can be done to prevent cross contamination and transmission of infectious material. High efficiency particulate air (HEPA) filters and UV chambers in the ventilation system can reduce the aerosol related contamination [24]. An UV chamber with HEPA filters is ideal because regular decontamination of filters is not necessary. If possible these filters should be installed directly above the dental chair with an air flow as such that the contaminated air can be filtered. In the dental practice the air flow should be from the waiting and administration area to the room with the dental chair. The contaminated air from the dental chair area should not be spreading or circulating into the non-treatment area. During patient treatment portable HEPA filters are recommended by CDC (2019) which can be placed in the vicinity of the patient's chair. This can reduce particle count including droplets in the room [32]. In addition to the ventilation and air circulation, use of UV germicidal irradiation should be considered. Bathroom air extractors should run continuously during consulting times. Generally no carpets are allowed in dental practices. Floor material and upholstery of the dental chair should have minimum stitching. The floor must be disinfected twice a day. The dental chair can be covered with plastic which can also be disinfected before and after patient treatment and at the beginning and at the end of the day. Medical waste can be disposed according to the local regulations. Staff should be educated with regards to all the infection control principles and practices.

In conclusion, infection control has always been important in dentistry, however, during epidemics and pandemics of air borne infections extra precautions are required. Generally in medical facilities, patients can only transmit pathogens through coughs, sneeze and direct contacts, whereas in dentistry with the creation of saliva aerosols the pathogens are literally removed from the nasopharynx and oral cavity, and spread around contaminating air and surfaces. In dental practices, many people such as the practitioner, assistant, patients, administration staff, cleaning staff and perhaps accompanying individuals are at risk. Standard precautions, although they are good, are not enough during this pandemic caused by the highly infectious and easily transmissible SARS-CoV-2. Adequate PPE and hand hygiene are unavoidable, however, hair and shoe cover should be considered. The sequence of consultation and scheduling of patient appointments and modification in the waiting area are also important. To minimise contamination by aerosols, mouth rinses

Table 1. Modifications required in the infection control in dental health-care settings during COVID-19 pandemic.

Area	Infection control measures
Before booking patient	Telephonically: • Do the diagnosis to determine urgency of treatment • If available, ask for most recent COVID results • Do the COVID screening through a questionnaire • If appointment is given, ask to come with a mask and one/none accompanying person • Ask patient to brush teeth and use mouth rinse before coming to the practice
Waiting area	• Place minimum number of chairs 3 feet apart • Remove all the unnecessary things such as toys and magazines • Make hand sanitizer available • Place COVID transmission related information on the wall • Make mouth rinse (peroxide-, iodine- or chlorine-based) available for the patient to use before treatment • Have a glass or plastic partition between waiting area and receptionist • Enough time must be allocated between appointments to follow infection control steps and minimise awaiting patients
Administration area	• Have minimum necessary staff or staff on rotation • Staff should be educated regarding COVID transmission • Staff should wear masks, follow hand hygiene and apply social distancing • On arrival everyday temperature measurement and COVID screening must be done for all the people entering the practice
Treatment area with dental chair	• Dental chair and whatever can be covered must be covered with plastic • Before and after treatment all the surfaces including dental chair must be disinfected with 70% alcohol • Minimum necessary things must be left out • Dental practitioner and assistant must wear high-collar long sleeve gown and plastic apron, gloves, mask, disposable hair and shoe cover and a facial shield (PPE) • PPE must not be removed immediately after treatment • After treatment unused material must be considered contaminated and should be processed or disposed appropriately
Treatment	• If possible use rubber dam • Use high and low volume evacuators • If possible do not use high speed handpieces and ultrasonic scalers
Instruments, DUWL	• Heat-resistant things and instruments must be sterilised • Sterilisers must be inspected and tested for the efficacy • Spay-wipe technique must be used to disinfect everything before and after the treatment • 70% alcohol or chlorinated compounds (2000 mg/L) can be used • DUWL must be disinfected by flushing with disinfectant • DUWL water must be replaced with appropriate disinfectant bearing in mind that the water is used in the patient's oral cavity
Floor	• Floor must be disinfected twice daily with 2000 mg/L chlorinated solution
Air, ventilation and general	• Air flow must be adjusted to allow clean air coming in to the treatment area from the rest of the surgery • Bathroom air extractors must be kept running continuously during consulting time. • HEPA filters with UV light must be installed above the dental chair • Or portable HEPA filters should be used placing as close as possible to the patient during treatment • UV germicidal irradiation should be considered • Biohazard waste must be disposed appropriately

before treatment, although it is an additional cost to the practitioner should be considered. Major alterations of practices are not economical and often not possible. Nevertheless, ventilators with HEPA filters can greatly reduce aerosols and the majority of aerosols can be extracted and filtered through these filters. These measures are summarised in Table 1. This will reduce aerial, floor and surface contamination. These measures and modifications would also prepare the dental fraternity for similar future experiences.

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