

COVID-19 and Dentistry: An Updated Overview of Dental Perspectives and a Recommended Protocol for Dental Care and Emergency Dental Treatment

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ABSTRACT

Aim and objective: This manuscript aims to provide an overview of the coronavirus disease-2019 (COVID-19) pandemic from dental perspectives, and presents standards and guidelines of dental care provision based on available research in this field as well as clinical experience and practice.

Background: The current COVID-19 pandemic caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is spreading around the globe and interferes with the provision of dental care for many individuals from different communities and backgrounds. A search for the literature on PubMed, ISI Web of Science, Scopus, EMBASE, and Cochrane Library from March 1, 2020 to December 30, 2020 was conducted. Also, the bibliographies included in the indicated articles were used to identify further literature. Recommendations by health authorities in different countries were also consulted.

Results: COVID-19 is causing many fatalities and is disrupting people's daily life and the economy in many countries around the world. Due to the potential of cross-infection through dental treatments, especially dental aerosol generation procedures, the dental profession has been disrupted during this pandemic. Dental care provision has been ceased completely or partially (limited to emergency or urgent treatment) in most countries around the world. Until this pandemic is controlled by new suitable treatments and/or vaccination, there is an urgent need to adopt immediate guidelines and standards for the safe provision of dental care to meet patients' demands, especially for the dental aerosols.

Conclusion: Guidelines and standards for dental treatment amidst the COVID-19 pandemic are required. This manuscript provides an overview of the COVID-19 pandemic from dental perspectives and presents standards and guidelines of dental care provision based on available research in this field as well as clinical experience and practice.

Clinical significance: This manuscript provides guidelines and standards for dental treatment and clinical management within dental settings amidst the COVID-19 pandemic, and resembles part of the quest to set the golden standards for dental care during the current circumstances.

Keywords: Aerosol, COVID-19, Dental care, Personal protective equipment, SARS-CoV-2, Viral transmission.

The Journal of Contemporary Dental Practice (2021): 10.5005/jp-journals-10024-3076

INTRODUCTION

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has spread all over the world and is causing a pandemic currently known as coronavirus disease 2019 (COVID-19).¹⁻⁶ The virus has many mutations so far (such as British, South African, and Brazilian strains); and this might influence epidemiology, spread, clinical presentation, and severity of COVID-19.^{7,8}

The clinical presentation of COVID-19 is widely variable and might differ according to age, gender, co-morbidities, and geographic area.⁷⁻²⁶ The affected individuals might be asymptomatic^{11,12} or have one or more symptoms including fever, cough, fatigue, shortness of breath, muscle ache, abdominal pain and distention, diarrhea, nausea, vomiting, anorexia, rhinorrhea, sore throat, chest pain/tightness, hemoptysis, eye redness, and skin rash.^{9,10,13-19} They might also have central nervous system symptoms (e.g., headache, undermined consciousness/confusion/dizziness, shivering, seizures, acute cerebrovascular disease, and ataxia), and peripheral nervous system symptoms (loss of taste (hypogeusia), loss of smell (hyposmia), skin numbness/tingling, undermined vision, and nerve pain).^{9,10,13-19}

Diagnosis and screening methods for COVID-19 suffer some pitfalls including false negative and positive tests and do not completely rule out the presence of the virus or the potential for viral transmission to others.²⁷⁻²⁹

Many vaccines and treatments for this disease were explored, and there is, as yet, no available undisputed cure against the

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How to cite this article: AL-Omiri MK, Al-Shayyab MH, Al Naze AA, et al. COVID-19 and Dentistry: An Updated Overview of Dental Perspectives and a Recommended Protocol for Dental Care and Emergency Dental Treatment. *J Contemp Dent Pract* 2021;22(5):572-586.

Source of support: Nil

Conflict of interest: None

SARS-CoV-2 virus.^{17,30–36} Therefore, the available methods to fight COVID-19 are concentrated at cross-infection control, prevention of disease transmission, and vaccination.^{37,27,30–40}

Dental procedures could produce aerosols and potentially spread the virus; consequently, dental treatment was mostly limited to the provision of emergency treatment including trauma, tooth pain, cellulitis, and dental abscess.^{41–49} Therefore, the number of dental patients who attended dental treatment was noticeably reduced during the pandemic.⁴⁵ Dental care provision is potentially associated with high risks due to aerosol associated treatments, the serious health consequences of COVID-19, the lack of undisputed diagnostic measures, the possibility of disease transmission by asymptomatic patients, and the lack of an undisputed cure for the disease.^{3,4,41–49}

To avoid the consequences of COVID-19 on public health and lives; the disease contagiousness and transmission were controlled via strict measures including countries lockdowns, curfews, social distancing measures, vaccination, intensive testing, contact tracing, early detection, isolation, quarantine, travel bans, border closures, introducing temporary hospitals, selecting specific hospitals for isolation and treatment of patients, and use of proper medical equipment and supplies (e.g., personal protective equipment (PPE) and intensive care equipment such as ventilators).^{4,27,30–40,50–54} This has also led to an interruption of dental and medical care provision and complicated patients' access to dental and medical care.^{3,4,41–46}

It is useful to classify different dental treatments to set an international standard for what treatments should be carried out during COVID-19 or any future infection outbreaks. Dental aerosols and transmission of COVID-19 should be considered by future guidelines in this regard.

This manuscript aims to provide an overview of the COVID-19 pandemic from dental perspectives and presents standards and guidelines of dental care provision based on available research in this field as well as clinical experience and practice.

MATERIALS AND METHODS

Scopus, ISI Web of Science, PubMed, EMBASE, Research Gate, Google Scholar, and Cochrane Library databases were searched for literature from March 1, 2020 to December 31, 2020. Also, the bibliographies included in the indicated articles and reviews were used to identify further literature on the topic. The search terms included "COVID-19", "SARS-CoV-2", "coronavirus", "novel coronavirus", "2019 novel coronavirus", "2019-nCoV epidemic", "coronavirus disease", "coronavirus pandemic", "coronavirus disease 2019", "pneumonia outbreak", and "severe acute respiratory syndrome-related coronavirus". These terms were also joined with terms including "dentistry", "dental care", "dental treatment", and "aerosols".

Full-text studies related to different aspects of coronavirus disease and published in English in peer-reviewed scientific journals were included in this review. Unpublished data and non-peer-reviewed articles were excluded. Opinions, non-focused articles, and non-evidence-based articles were excluded. Redundant and replicate articles were also excluded.

About 40,000 titles were obtained through the search. After application of the inclusion and exclusion criteria and author dialogue; 153 papers were included in this study and focused on major aspects of COVID-19 and COVID-19 in dentistry.

The included titles and articles were appraised by individual authors to attain preliminary conclusions concerning each subject matter before evaluating and discussing the conclusions with other

authors to reach a final agreement on different headings and titles included in the text.

RESULTS

COVID-19 Potential Spread within Dental Settings

The SARS-CoV-2 incubation period varies from 1 to 14 days without symptoms,^{39,55} and the virus is contagious during the incubation period.^{39,50,56,57} Failing to consider this might potentially increase the risks of dental care provision amid this pandemic.

Moreover, no evidence-based research is currently available on humans to indicate whether individuals recovered from COVID-19 can acquire long-term or permanent immunity, become re-infected, have virus re-activation or keep shedding the virus following their pharyngeal swabs tested negative, and therefore turn into asymptomatic carriers who potentially infect others.^{58–62}

Besides, SARS-CoV-2 might have various ways of transmission between humans.⁶³ Other coronaviruses (e.g. SARS-CoV) might be incorporated into airborne dust, sand, and other pollutants; and this should also be considered a possibility and further investigated for SARS-CoV-2.⁶⁴

SARS-CoV-2 was first thought to transmit through touching the mouth, nose, or eye after direct or indirect contact of infected secretions or surfaces.^{50,65,66} Also, sneezing or coughing would cause infected fluid droplets to enter the mouth, nose, or eye of adjacent individuals, and cause the infection.^{50,65} Also, the virus might pass through damaged skin surfaces to cause infection.⁶⁷ Fecal-oral transmission is also possible as the virus is present in stools and wastewater.⁶³

Nevertheless, the virus is currently confirmed to be primarily airborne via aerosols that are produced during breathing, talking, coughing, or sneezing and stay in the air for long periods (hours) and travel for longer distances (4–8 m), and thus contaminate surfaces and cause disease if inhaled by others.^{68–74} Also, the virus can be present in very small aerosols of 0.25 μm in diameter.⁷⁰

Also, aerosol transmission is more difficult to control, is associated with more disease spreading, and necessitates the application of tougher infection control measures (including proper PPE).⁷⁵ Potential aerosol transmission of SARS-CoV-2 should be combated by social distancing, hand washing, proper ventilation, suitable PPE (including face masks), and decontamination of protective wear and toilets.^{70,72,76}

Furthermore, potential disease transmission by asymptomatic carriers is high due to aerosols even during breathing or speaking within confined spaces and during light and heavy exercise.^{73,77}

Moreover, the upper respiratory tract (including the throat and the oral cavity) is a potential source for SARS-CoV-2 virus infection because it includes cells with ACE2 receptors (e.g., oral mucosa and salivary duct cells) and produces high viral loads in saliva and secretions, and thus is a potential source of infection and virus replication.^{78–84}

Also, many dental procedures including the use of scalers, handpieces, piezoelectric surgical instruments, electro-cautery instruments, and three-in-one syringes; produce massive loads of aerosols that consist of saliva, water, blood, plaque and microbes, and reach different surfaces as well as the body and breathing zones of dental care providers.^{41–44,84–93} Ultrasonic scalers could produce aerosols that remain in the air approximately for 30 minutes, move for several feet, and contaminate faces, heads, chests, and arms of dental care providers as well as the interior surfaces of the surgical masks they have worn.^{88,91}

COVID-19 Impacts on Dental Care Provision

Fearing from the disease consequences on public health and lives; many authorities responded and applied strict measures including countries lockdowns, curfews, social distancing measures, travel bans, and border closures.^{4,27} This led to interruption of dental and medical care provision, limited dental treatment to emergency treatment (trauma, tooth pain, cellulitis, and dental abscess), and affected patients' access to dental and medical care.^{3,4,41–43,45–49}

Some researchers reported COVID-19 infections or deaths among dental professionals; however, they did not specify whether providing dental treatment for infected patients was the cause for this or not.^{41,42}

During COVID-19, the numbers of patients who demanded non-emergency dental treatment were dramatically reduced, the numbers of patients who sought emergency dental treatment were declined, most patients attended for treatment of oral and dental infections, very small number of patients attended to treat trauma, and endodontic emergencies (mostly irreversible pulpitis) were the most reported cause for seeking dental treatment.^{45,94} Vital pulp treatment reduces the treatment time and is considered useful to reduce the chance of infection.⁹⁴

Teledentistry and consultations via the internet might help educate patients and offer some professional preventive dental advice.^{46,95}

Protection against COVID-19 Transmission and Available Guidelines

Previous literature regarding provided dental care during the COVID-19 pandemic included some suggestions and guidelines for the prevention of COVID-19 transmission during dental treatment amid the COVID-19 pandemic,^{41–43,47,48,84,93,94,96–102} or reported what type of treatment was carried out at some dental hospitals.^{45,46,94} However, previous studies did not report treatment to COVID-19 confirmed cases.^{41,42,45,46,94}

Nevertheless, the current evidence showed that wearing masks would reduce positive COVID-19 tests among healthcare professionals.¹⁰³ Wearing masks and active room ventilation (such as using HEPA filters; high volume high efficiency particulate air filters) decreases aerosol infection by 5–10 times.¹⁰⁴ However, some researchers suggested that surgical masks and other kinds of masks might not be adequate to completely prevent the passage of the virus.¹⁰⁵

Respirator masks can be utilized for a longer time (up to 8 hrs of continuous use) and offer 10 times better protection than surgical masks if they are perfectly fitted and suitable in size for the user.¹⁰⁶ They include different types of filtering facepiece respirators (EU standard: FFP1, FFP2, FFP3; USA standard: N95, N99, N100). FFP2 respirators (EU standard) are comparable to N95 respirators (USA standard), meanwhile, FFP3 respirators are comparable to N99.^{106,107} Currently, it is recommended by some health authorities to wear FFP3 respirators for aerosol-generating medical procedures.^{107–109} Conversely, FFP1 respirators are not adequate for safety against COVID-19.¹⁰⁷

The current evidence showed that surgical masks do not protect against COVID-19 and FFP3 should be used instead.¹¹⁰ In addition, the surgical masks are loose fitting and allow passage of the virus.¹⁰⁵ Moreover, some evidence indicated that even using multiple surgical masks would not prevent the passage of particles loaded with viruses.¹¹¹ Therefore, when airborne infections are considered, surgical masks should not be used instead of respirator masks unless there is no alternative when respirator masks are not

available.¹¹¹ Nevertheless, medical personnel safety should not be compromised in any situation.

The efficiency of masks/respirators was not tested before within dental settings especially during aerosol-generating procedures. After all, the virus is only 120–160 nm in size,¹¹² and no guarantee that it will be prevented from passing through masks/respirator fabric/textile or imperfectly fitted masks/respirators.

Also, the N95 respirator does not provide 100% protection against viruses in aerosols.^{113–115} In addition, the N95 mask might cause discomfort and might not be perfectly fitted especially with the presence of facial hair, and this will allow passage of the virus.^{113,114} A meta-analysis review concluded that N95 respirators were found to provide no better protection against influenza viruses.¹¹⁶ Another meta-analysis of four randomized clinical trials revealed that surgical masks, as well as N95 respirators, were associated with a similar incidence of viral laboratory respiratory infections (coronavirus included) as well as clinical respiratory disease.¹¹⁷ Others also found no difference between N95/P2 respirators and surgical medical masks in protection against influenza infection among healthcare workers.^{105,118,119}

Nevertheless, some researchers suggested that N95 respirators performed better than surgical masks when used against influenza and bacterial infections transmitted via droplets.¹²⁰ Moreover, some investigators demonstrated that surgical masks could reduce seasonal coronavirus RNA in aerosols produced by patients.⁶⁹ However, no study investigated this for the COVID-19 virus within dental settings.

Alternatives that potentially provide more protection in this regard are powered air-purifying respirators (PAPR), especially if medical personnel have facial hair and N95 cannot be fit tested.^{107,121,122}

Another issue with respirators and other PPE is that they might be associated with discomfort, skin allergy, and skin pressure ulcers and injuries, especially if worn for a long time and if FFP3 were used as the high-level respirators.¹²³

The literature includes research of some previously developed devices that can clean and filter the air within clinic environments.^{90,104,124–128} However, not enough studies or evidence is available to show that these devices could totally clear the air from aerosols and microorganisms, especially viruses and SARS-CoV-2 in particular.

Using air cleaners and downward ventilation systems might help to reduce the exposure of dental professionals and staff to aerosols if placed in certain areas within dental clinics as they would direct aerosols away from the body and breathing zone of healthcare workers.^{90,104,124,125,128} However, some aerosols will eventually reach the body and breathing zone of dental professionals and this might be influenced by many personal and environmental factors.^{88,91,127} It is important to notice that displacement ventilation (upward ventilation) is not suitable to use for hospital rooms if the respiratory infection is a possibility.¹²⁶

On top of all this uncertainty regarding protection against viruses and the available PPE, it is established that asymptomatic virus carriers are capable of shedding the virus and transmitting the disease without having any symptoms.^{11–13,17–19,129} All these factors make dental treatment hazardous with high potentials for spreading the disease.

Since no previous research is available on what dental procedures could transmit the COVID-19 virus and what procedures do not; logic and previous recommendations regarding cross-infection should be taken into consideration. For instance, laryngologists

and anesthetists experiences in this regard should be taken into consideration as they carry out procedures that produce aerosols and involve direct contact with the hot spots of the presence of the virus, and the working dental field is similar in this regard.^{83,130-134} Moreover, previous studies showed that laryngologists were among the most severely hit healthcare workers with the COVID-19 during the early outbreak of this pandemic.^{83,133,134}

Previous research suggested personal protective equipment (PPE) used for tracheostomy might give an insight into the PPE required for dental procedures especially for the treatment of infected patients or patients who might be infected.¹³² This includes head caps, shoe covers, goggles, face shields, fluid repellent full gowns, and double surgical gloves. Regarding the masks, the N99 or FFP3 are better to use unless these are not available, then N95 or FFP2 can be used and it has been suggested to possibly cover an N95 or FFP2 respirator with a surgical medical mask to allow multilayer protection and doffing.¹³²

Many authorities and researchers issued guidelines for dental care during the COVID-19 pandemic to avoid disease transmission and to provide protection to patients and dental staff during dental care provision.^{41-49,84,93-102} However, different recommendations included different dental care protocols and guidelines. Also, some recommendations were not based on clinical experience or research within dental settings and were not evidence based.

Table 1 summarizes major recommendations for dental treatment presented in the literature.^{34,41-49,65,68-74,90,93-102,104,107,111,122,124-128,132,135-145}

DISCUSSION AND RECOMMENDATIONS

The results of the literature search pointed out the lack of standard evidence-based guidelines or protocols for dental management and dental health care during the COVID-19 pandemic. Many issues raised the alarm of the threat posed by dental treatment during the COVID-19 pandemic.

The results also highlighted the presence of genuine concerns regarding the potential of transmission of the disease from patients to dental staff, from dental staff to patients, from patient to patient as well as from clinic surfaces/instruments to patients. This is due to many issues and facts that were presented via the results above including:

- The dental literature lacks enough evidence-based studies on this subject.
- Patients might attend the clinic asking for treatment whilst infected with COVID-19 and exhibit no symptoms of COVID-19 (asymptomatic patients). They can potentially spread the disease through aerosols generated during speaking or breathing even without any treatment or dental procedures that do generate aerosols.
- Patients might test negative for COVID-19 and still be infected and spread the disease.
- Patients might be declared healed and free of the disease and possibly still get reinfected or have reactivation of the virus. Still, they can potentially spread the disease.
- Links of saliva and salivary glands to COVID-19 virus: The virus has the potential to infect salivary glands, and has an affinity to ACE2 receptors that are present in oral mucosa, throat, and salivary glands. This makes the oral cavity a source of infection.
- The presence of high viral load in the saliva of infected patients (regardless of being asymptomatic or having symptoms of COVID-19) increases the chance of infection.
- This disease has no confirmed treatment or cure yet, is very contagious, and has many transmission routes that can all occur within dental clinics.
- The fact that breathing, talking, coughing, and sneezing produce aerosols that can reach the body and breathing zone of the operator.
- There is no evidence base of the level of efficiency of PPE against COVID-19 within dental settings, and even during other treatments. Although they provide proven protection, face masks are still facing controversy as they cannot provide 100% protection against virus passage.
- The nature of dental care involves very close contact between dental care professionals and patients. This is also complicated by the relatively long dental treatment procedures.
- The nature of dental care being applied within the hot spot areas of the virus (oral cavity with salivary glands, saliva, and mucosa) or very close to the main hot spots of the virus (the respiratory system).
- The nature of the dental treatment being associated with the generation of many aerosols during patient management.

Consequently, health authorities in most countries were cautious regarding the provision of dental care to the public during this COVID-19 pandemic. This could potentially impact the economy as well as deprive people from obtaining required treatment leading to increased impacts of dental disease on individuals and societies.

However, both patients and dental staff health are important, and all measures should be taken to protect everyone regardless of how hard are the adopted decisions for this purpose.

Therefore, dental care providers should demonstrate high professional decisions regarding the provision of dental care to patients taking into consideration the real need for dental treatment, the burden and distress caused by the dental problem, patients wellbeing and general health, the availability of adequate PPE and dental settings for treatment, the spread and transmission of COVID-19 within the country or community (threat level), and capacity to provide professional care whilst maintaining the safety of both patients and dental staff.

Therefore, from the above search of the literature and the content of published articles in this regard, a clear lack of enough evidence-based research in this area is obvious, and this is alarming taking the genuine threat posed by dental treatment in the transmission of this disease. Consequently, urgent further research is required in this regard to find solutions to virus-infected aerosol generation in dental clinics, to establish what levels of PPE are required during dental treatment, to reveal the role of dental care provision in the transmission of COVID-19, to indicate which dental procedures can be safely carried out, and to set evidence-based guidelines for dental treatment during this pandemic as well as any future infection outbreaks.

Also, obtaining pending evidence-based information, it is rational to deal with each individual who attends the dental clinic as a possible cause for COVID-19 infection even if they have no symptoms or have recently recovered and tested negative for the virus.

To avoid cross-infection and transmission of COVID-19 within dental settings, the following are recommended comprehensive guidelines and protocols related to different aspects before, during, and after dental care provision including issues related to patients, clinic settings, and staff in an attempt to obtain the safer provision of dental care and treatment during the COVID-19 pandemic, until an evidenced-based solution can be achieved for managing the dental

Table 1: Suggested literature recommendations and protocols for dental management during the COVID-19 pandemic

<i>Recommendations and guidelines in the literature</i>	<i>References</i>
Patient preparation	
<i>In home</i>	
Interview over the phone or internet.	41–43,45–49,93–102
Patient triage for treatment in home or clinic based on case emergency and COVID-19 inquiry.	41–49,93–102
<i>Before treatment</i>	
Limit the presence of the companions.	41–43,47,48,93
Referral and report to health authorities if COVID-19 positive or has signs and symptoms of COVID-19.	41–43,47,48,93
Limit patients numbers, limit treatment time, and ensure adequate ventilation.	41–43,47,48,93,96–98
Implement strict measures for protection against the potential of COVID-19 infection.	41–43,47,48,93,96–102
Provision of 60–85% alcohol gel to clean hands, then provision with gloves, masks, gowns, head covers, and shoe covers before getting into the main clinic area.	41–43,47,48,93, 96–102
Measure the patient's temperature.	41–43,47,48,93,96–102,135
Strict physical distancing, wearing masks in the clinic, and marking out a controlled distance on the floor.	65,68–74
Clear accessories in the waiting area and keep patients' belongings in the waiting/reception area.	41–43,47,48,93,96–102
<i>During treatment</i>	
Rinse patient's mouth for 1–2 minutes using a mouth rinse (1–1.5% hydrogen peroxide, 1–2.3% povidone-iodine, or 0.05–0.1% cetylpyridinium chloride).	102,136,137
Treatment utilizing the least invasive procedures, non-aerosol-generating techniques, rubber dam application, both low and high surgical suction (suction tip diameter of 8 mm or more), extraoral radiography, and adequate ventilation.	41–43,47,48,93,96–102,138
Prescribe medications based on risk assessment vs benefits	34,139,140–142
<i>After treatment</i>	
Disinfect patient's hands with 70–85% alcohol. Place patients' masks, head covers, shoe covers, gowns, and gloves in sealed plastic bags and disposed of as hazardous medical waste following local authorities' guidelines.	41–43,47,48,93,96–102
<i>Clinic preparation</i>	
Adequate ventilation	
Use air filters/cleaners and downward ventilation systems	41–43,47,48,93,96–102,104
Avoid rooms without windows or where windows cannot be opened unless prepared with effective mechanical ventilation that extracts air in the room and replaces it with fresh air.	90,104,124–128
Clean and disinfect all clinic surfaces before and after each patient using 70% isopropyl alcohol, 0.1% sodium hypochlorite, or an evidence-based solution.	41–43,47,48,93,96–102
Adequate disposal of medical and hazardous clinic waste following the recommendations of local authorities.	41–43,47,48,93,96–102
Clean and disinfect toilets in the clinic. Flushing of the toilet while its cover is closed to reduce the aerosol spread in the air.	143
<i>Staff preparation</i>	
Vulnerable staff should not treat COVID-19 or suspected COVID-19 patients (e.g., pregnant and medically compromised staff).	144
For staff safety (dentists, dental assistants, receptionists, cleaners), adequate PPE should be strictly applied.	41–43,47,48,93,96–102
Donning before treatment: removal of rings, bracelets, jewelry, and all other objects before wearing PPE. Then, wash hands with soap for 60 seconds, then hand disinfection with a 60–85% alcohol gel for 1 minute. Then, put on the first pair of surgical gloves, mask, goggles, head caps, face shields, water-resistant full gowns, and shoe covers. Then, disinfect the gloved hands with a 60–85% alcohol gel for 1 minute, and then wear the second pair of surgical gloves.	41–43,47,48,93,96–102
Best masks to use are N99, N100, filtering facepiece respirators (FFP3), or powered air-purifying respirators (PAPR). If not present, use an N95 or FFP2 respirator and cover with a surgical medical mask to allow multilayer protection and doffing.	107,111,122,132
FFP3 or PAPR should be used if the patient is a highly suspected/confirmed COVID-19 case, aerosol-generating procedures are to be used, and if the staff has facial hair that prevents fit testing of N95 mask.	107,122,132
Doffing following treatment: disinfect the double gloved hands first then remove the gown, top gloves, goggles/face shield, head cap, shoe cover, mask, and then finally the internal gloves. Use alcohol rub following removal of each item of the used PPE.	41–43,47,48,93,96–102
Carefully place all disposable PPE in sealed disposable plastic bags and designate to the hazardous clinic waste, then dispose following local authorities guidelines.	41–43,47,48,93,96–102
After treatment and doffing, wash hands with soap for 60 seconds; then hand disinfection with a 60–85% alcohol gel for 1 minute.	41–43,47,48,93,96–102
Disinfect and clean reusable PPE while wearing double thick gloves or surgical gloves, fluid-resistant surgical masks, and fluid repellent full gowns. Goggles and face shields are disinfected with 70% alcohol.	41–43,47,48,93,96–102
Using ozone for disinfection of reusable PPE and instruments.	145
Use the hospital or professional laundry services for medical scrubs and clothes. The clothes should be washed separately in a washing machine with half its capacity or less, and at the highest possible temperature endured by the clothes (suggested washing cycles: 30 minutes on 60°, or 10 minutes on 80–90°).	41–43,47,48,93, 96–102

aerosol. The following recommended guidelines and protocols are drawn from clinical experience, published research, and international implemented and suggested guidelines in countries including Jordan, UK, Italy, France, Spain, USA, Canada, Australia, and China.^{41-49,84,93-102}

In addition to the following recommendations and guidelines in this manuscript, dental professionals should also consider recommendations and guidelines issued by their countries and health authorities as well as consider their national COVID-19 alert level. Also, dental professionals should consider ethics and morals when they make decisions regarding the provision of dental care to protect the interests of their patients as well as dental professionals.¹⁰⁸ Safety of both dental health care personnel and the patients should never be compromised under any circumstances.

Recommended Guidelines and Protocols for Dental Care Provision during COVID-19

Based on the above results and discussion, the following are suggested recommendations, guidelines, and protocols for dental care provision during the COVID-19 pandemic.

Classification Protocol for Treated Patients and Provided Treatments

Considering the potential of disease transmission during dental care provision, the dental patients can be categorized into high, medium, and low-risk patients (Flowchart 1).

Flowchart 2 presents a classification of the urgency of demanded dental care, triage of cases, and the management that should be offered.^{41-49,93-102}

Severe or uncontrolled symptoms that cannot be endured or handled by patients even after the phone/online consultation are treated within clinics/hospitals. In this context, treatment might be offered for conditions that jeopardize the airway, compromise health, entail severe pain, and hinder function.^{41-49,93-102,146,147}

Table 2 presents various dental treatments that might be performed during the COVID-19 outbreaks if adequate cross-infection control and the following guidelines and recommendations are applied until further evidenced-based solutions are proven.^{41-49,93-102,148,149}

Patient Preparation

Flowchart 3 presents a recommended protocol for the preparation and treatment of patients who seek dental care during the COVID-19 pandemic.

Dental treatment must commence at home.^{41-43,45-49,93-102} Then, patients' complaint is categorized as non-urgent, urgent, or emergency to decide if the patient can be managed over the interview or should attend the clinic for assessment and treatment (Flowchart 2).^{41-49,93-102} Only give appointment to attend for treatment in the clinic if the COVID-19 appraisal (Table 1) is negative (Flowchart 2).^{41-49,93-102}

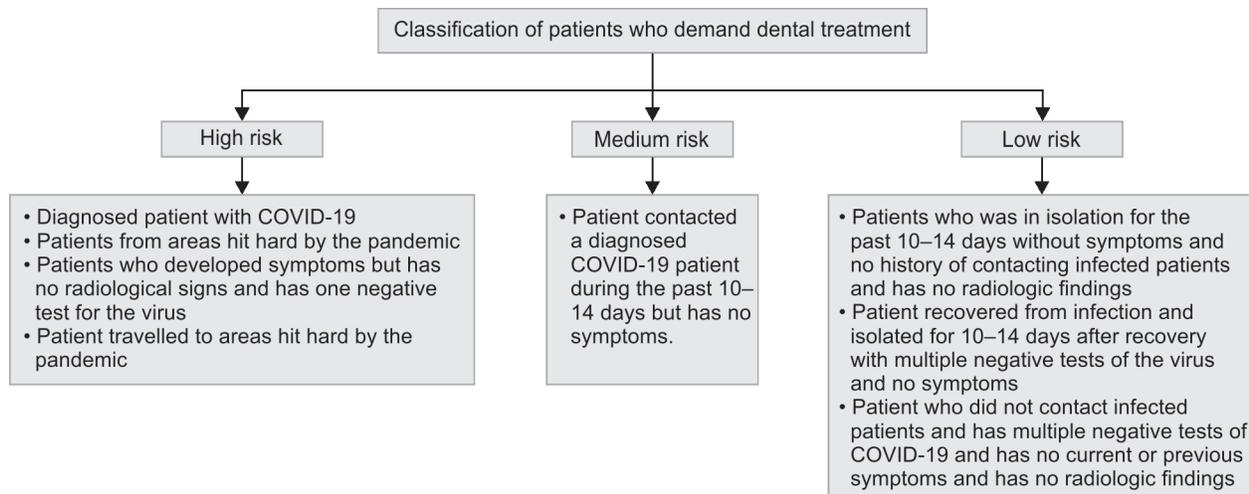
Confirm the appointment, and instruct patients to stick to appointments (avoid attending earlier to minimize the number of individuals in the clinic) and avoid bringing companions unless necessary (e.g., companions of vulnerable patients or children). Necessary companions should be interviewed via online/phone similar to patients to rule out COVID-19 issues (Table 1). Then, arrange patient transport with authorities during curfews, otherwise, patients arrange for their transport.

Once arrived, patients allowed into the clinic only if the reception, staff, and clinic are ready. Once inside, the patient (and necessary companion) is requested to wear masks all the time, follow the guidance marks on the floor, and keep a distance from others.^{65,68-74} The virus is airborne and the previous recommendations of 2 meters distance are not effective alone.^{65,72} However, both wearing the masks and keeping distance should be applied together to reduce the chance of disease transmission.⁶⁸⁻⁷⁴ Having an intermediate zone/area between the clinic entrance and the rest of the clinic as a transient station to prepare patients is advisable.

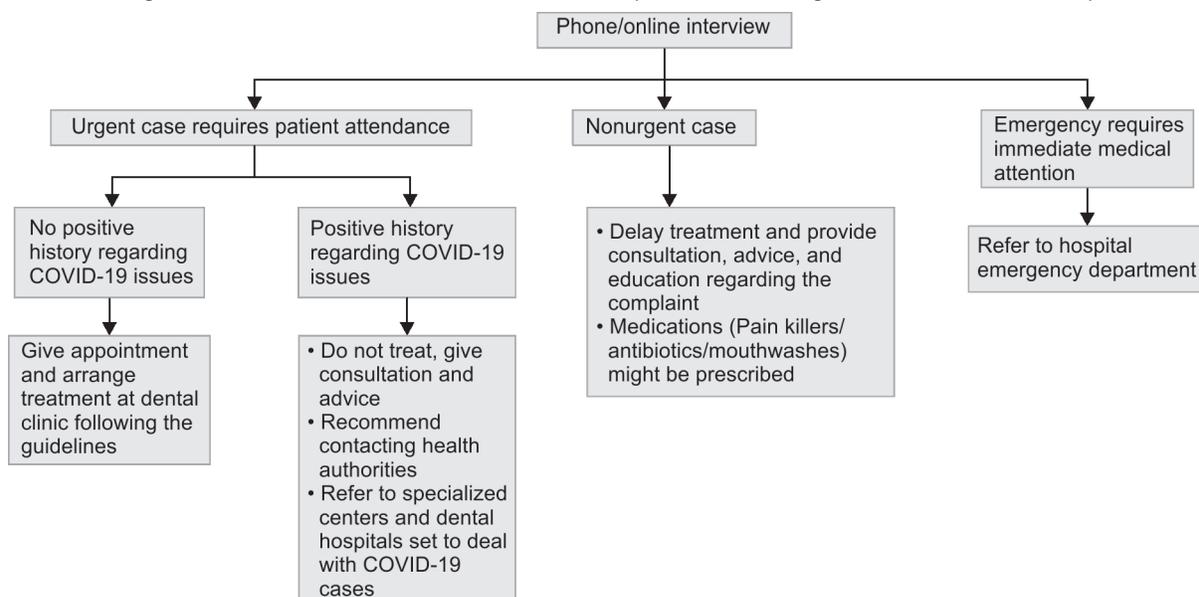
Patients (and necessary companion) temperature should be measured using a portable thermometer.^{41-43,47,48,93,96-102,135} Most recommendations identify alarming temperatures between 37.3°C and 38°C.^{41,47,100,135} We consider temperatures ≥37.5°C alarming following most literature; especially if accompanied with cough or breathing problems. However, even if the dental infection is suspected to cause the fever, avoid treatment and refer to specialized dental hospital settings unless the patient is confirmed COVID-19 free following proper testing and medical advice.

The dentist should conduct comprehensive patient evaluation including chief complaint, dental and medical histories, and appraisal of COVID-19 issues (Table 1). The treatment need is assessed and the required treatment is determined. The treatment is then performed with proper ventilation, following least invasive ways, using non-aerosol producing procedures (if possible), using

Flowchart 1: Flow diagram of patient classification according to the risk of COVID-19 disease transmission



Flowchart 2: Flow diagram of how to reach the decision to treat or not for patients demanding dental care amid COVID-19 pandemic



rubber dam (decreases 70% of airborne elements), using low and high volume surgical suction (≥ 8 mm suction tip diameter), and extraoral radiography (to reduce cough and salivation that associate intraoral radiographs).^{41-43,47,48,93,96-102,138}

Acetaminophen (paracetamol) pain killers can be prescribed, and if not effective; other drugs (such as ibuprofen) can be prescribed after weighting advantages vs risks.^{34,139,140}

If the patient is discovered to be COVID-19 positive after treatment, trace, isolate and test all staff and individuals who contacted him/her; particularly if treated with aerosol producing treatment. The patients' mental health should be also considered as COVID-19 was associated with stress and anxiety.^{150,151}

Clinic Preparation

Close the outer doors of the clinic at all times to control the flow of patients. Use transparent glass shields between patients and receptionists at the reception front desk. Use the least number of chairs in the reception/waiting area, and set them apart.^{65,72} Clear the reception/waiting areas from accessories including decoration objects, tables, banners, flyers, newspapers, magazines, and other objects that increase cross-infection.^{41-43,47,48,93,96-102} Besides, automated and digital documentation should substitute paperwork including prescriptions, files, referrals, invoices, and receipts. Limit the daily numbers of patients (and staff if possible) to a minimum and allow 45 minutes between appointments for staff and clinic preparation.^{41-43,47,48,93,96-98}

Avoid central air conditioning and separate clinic room ventilation from other areas to avoid disease transmission as the virus is airborne and the dental treatment produces aerosols.⁴⁷ Also, avoid air conditioners that use split air units except that work in extraction method as the virus might settle in the unit and cause infection later. Air fans should be installed to move air away from working staff.⁴⁷ Air cleaners/filters and downward ventilation help to move aerosols away from staff, reduce aerosols in the atmosphere, and reduce surface contamination.^{90,104,124-128,152}

Furthermore, plan aerosol producing treatments at the end of the day, carry them out in a separate room or negatively

pressurized rooms with downward ventilation (if present), and avoid rooms without windows (or permanently closed windows) unless fitted with mechanical extraction ventilation that introduces fresh air to the room.^{41-49,93-102} Also, use rubber dam and surgical suction to reduce and guide aerosols away from staff, patient, and surfaces.^{41-49,93-102,138} Then, ventilate the clinic for 60 minutes and disinfect all instruments, devices, equipment, and clinic surfaces. The air can be disinfected utilizing disinfectant sprays, filters, or ultraviolet light.^{90,124-128,143,152,153}

If available, use treatment rooms alternatively to give more time between treatments (especially if generate aerosols) in each room and allow better clinic ventilation and disinfection. Ventilate clinics 15-30 minutes between treatments unless aerosols are generated then ventilate for 60 minutes.^{41-49,93-102}

The treatment room, dental chair, materials, instruments, and other devices should be regularly maintained, properly functioning, disinfected, and ready before treatment to ensure the shortest and most effective treatment session. Use aluminum foil, cover plastic sheets, and plastic wrap to cover clinic surfaces (include door handles and reception area), working surfaces (include trolleys and bench cabinets), and devices (include computers, light curing units, amalgamators, and X-ray machines) to decrease surface contamination. Keep cabinets, drawers, material stores, and doors closed to avoid contamination.⁴⁷ Also, the spittoon is better be dismantled/uninstalled from the dental unit, and it should not be used as this poses a threat of cross-infection.

Use disinfectants (0.1% sodium hypochlorite, 70% isopropyl alcohol, or any evidenced disinfectant) to clean and disinfect all clinic surfaces (including the dental chair, waiting area, reception, door handles, devices, clinic floors, desks, tables, and chairs) following each session of non-aerosol producing treatments, after each aerosol producing treatment, and after treatment of each potential COVID-19 patient.^{41-49,93-102}

Suitable PPE, disinfectants, autoclaves, and sterilization equipment should be present and properly functioning all the time. Employ professional laundry service or install a washing machine for washing clinic clothes, linen, and scrubs.

Table 2: Classification of types of dental situations and dental care treatments that can be encountered by dental professionals amid COVID-19 pandemic outbreaks

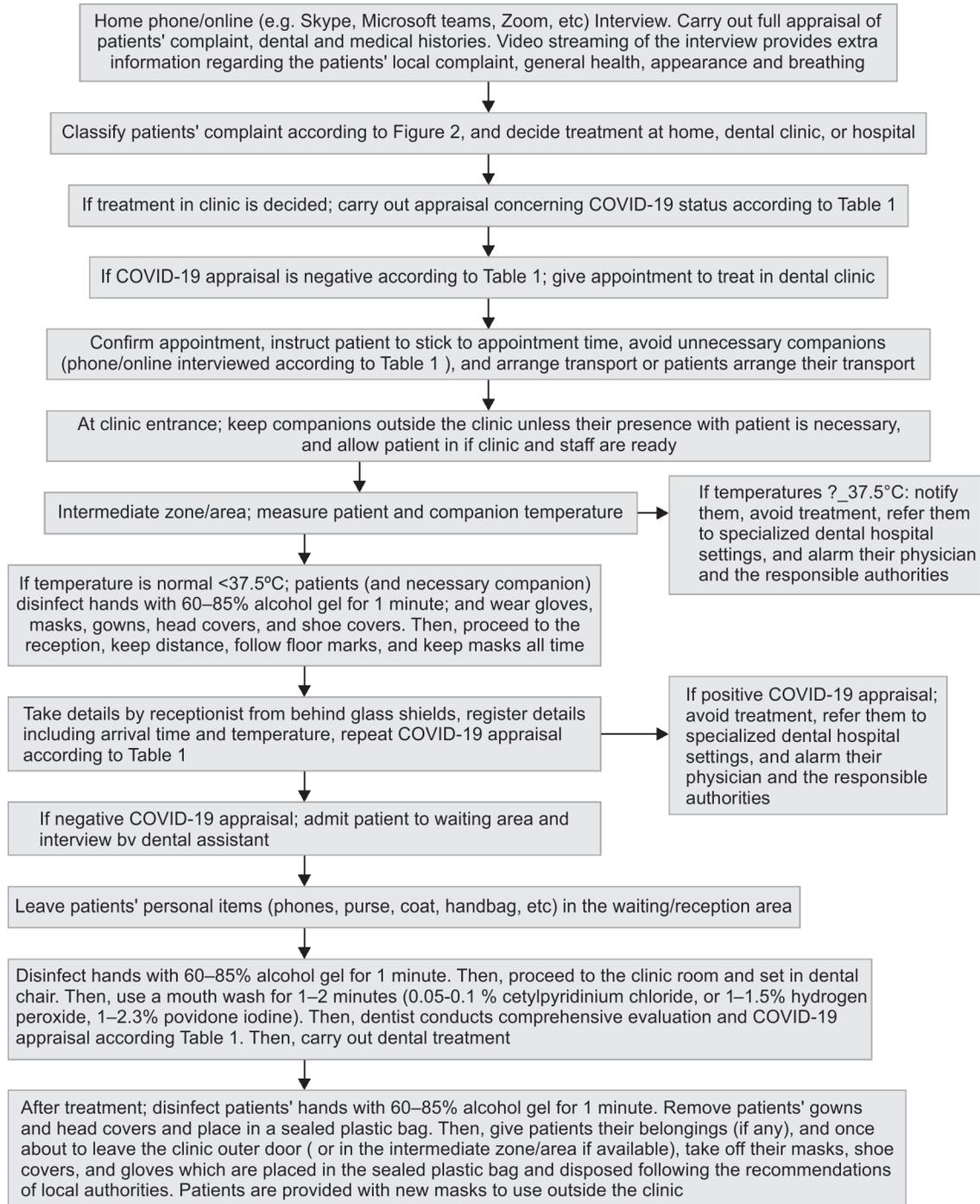
Treatment	Emergency: refer to hospital emergency department	Urgent: treat within dental settings	Nonurgent: offer advice, education, consultation, and medications
Surgical	<ul style="list-style-type: none"> • Injuries involving the airway (life-threatening). • Bleeding/hemorrhages (such as midfacial bleeding). • Injuries endangering the vision. • Severe fractures with CSF leak, risk to the eye/orbit, or near arteries or facial nerve. • Treat to prevent morbidity and difficult secondary surgical constructions. • Stabilize other fractures then resume once the patient is COVID-19 free. • Infections, dental abscess, cellulites, or swelling associated with trismus, limited swallowing, or endanger airway, eye, or body spaces. Treat by drainage and medications, and manage the cause later (e.g., tooth extraction or endodontic treatment). • Inhaled or fractured tooth portion. • Epistaxis and nasal packing removal/insertion. 	<ul style="list-style-type: none"> • Dento-alveolar trauma including alveolar bone or tooth fracture and tooth avulsion. Manage conservatively without aerosols generation. • Fractured teeth with dangling fractured pieces beyond repair or hopeless teeth with lingering pain and swelling not relieved with medications. Manage by extraction without aerosols generation. • Dry socket. Manage conservatively by simple irrigation with surgical suction and medications. • Removal of socket dressing or non-resorbable sutures to prevent infections if removal is postponed. • Pericoronitis if recurrent and/or associated with spreading swelling or/and trismus. Spreading or recurrent local infection not risking airway, body spaces, or eye. Manage by drainage, tooth extraction, and/or medications. • Expanding localized dental abscess or swelling not risking airway, body spaces, or eye. Treat by drainage and medications, and manage the cause later (e.g., tooth extraction or endodontic treatment). • Mobile fractured teeth portion that might be inhaled or swallowed. • Oral lesions including ulcers are inspected and biopsied if malignant lesions are suspected. 	<ul style="list-style-type: none"> • Simple pericoronitis treated by advice to use analgesic, mouth wash, and tender tooth brushing. • Recurrent oral ulcers. • Postpone all elective surgical procedures.
Periodontology	<ul style="list-style-type: none"> • Periodontal infections or abscess that risk body spaces or the airway. Treat by drainage and medications, and manage the cause later (e.g. affected tooth or foreign body). Avoid aerosol-generating procedures. 	<ul style="list-style-type: none"> • Expanding, persistent, and recurrent periodontal abscess/perio-endo lesions. Treat by drainage and/or medications. • Manual scalers/curettes might be used if required during acute periodontal incidents. • Avoid Aerosol producing instruments: ultrasonic scalers, piezoelectric machines, three-in-one syringes, and cauteries. 	<ul style="list-style-type: none"> • Chronic periodontitis/gingivitis. Offer oral hygiene and plaque control advice. • Postpone elective periodontal scaling and root planning till the patient is COVID-19 free.
Implantology	<ul style="list-style-type: none"> • Inhaled or swallowed implant component, fractured pieces of any implant parts, or fractured pieces of an implant-supported restoration. 	<ul style="list-style-type: none"> • Loose implant prosthesis or components that could separate and get inhaled or swallowed including loose screw/screw-retained prosthesis (particularly single crowns), debonded prosthesis, loose abutments, loose cover screw, loose healing gingival formers/caps, and mobile parts of fractured implants, screws, abutments, or prosthesis. • Implants moved into tissues, nerve space, or sinus. • Periimplantitis particularly adjacent to critical anatomic structures. Treat by implant removal, debridement, and/or medication. • Uncovered implants before stage-two surgery. Treat by replacing the cover screw with a healing cap or gingival former, and postpone treatment till the patient is COVID-19 free. • Removal of membranes, dressings, or non resorbable sutures to prevent infections. 	<ul style="list-style-type: none"> • Second-stage surgeries, prosthetic treatments, and other elective implant treatments should be deferred till the patient is COVID-19 free.

Contd...



Contd...	Emergency: refer to hospital emergency department	Urgent: treat within dental settings	Nonurgent: offer advice, education, consultation, and medications
Treatment			
Prosthodontics	<ul style="list-style-type: none"> Inhaled or swallowed prosthesis or fractured pieces of prosthesis 	<ul style="list-style-type: none"> Debonded/loose prosthesis or components that could separate and get inhaled or swallowed including bridges, crowns, post crowns, or endodontic posts. Manage by temporary cement for prosthesis and temporary filling for endodontic post space. Soft tissue injury or sensitive abutment exposure due to fractured or sharp restorations. Manage by rounding the sharp edge in the lab after prosthesis disinfection then cements it temporarily, or use temporarily cemented prefabricated temporary crowns to cover sensitive abutments. 	<ul style="list-style-type: none"> Postpone fabrication of prosthesis including partial dentures, complete dentures, crowns, and bridges until the patient is COVID-19 free.
Endodontic	<ul style="list-style-type: none"> Inhaled or swallowed endodontic instruments. Infection or abscess that risk body spaces or the airway. Treat by drainage and medications, and manage the cause later (e.g., affected tooth or foreign body). Avoid aerosol-generating procedures. 	<ul style="list-style-type: none"> Persistent irreversible pulpitis and a dental abscess that does not react to the medication. Treat using rubber dam by exposure of coronal pulp, use devitalizing material, then temporary filling. 	<ul style="list-style-type: none"> Postpone elective endodontic treatments or re-treatments of asymptomatic teeth until the patient is COVID-19 free.
Orthodontics	<ul style="list-style-type: none"> Inhaled or swallowed separated or fractured piece of orthodontic appliance or components 	<ul style="list-style-type: none"> Debonded brackets. Treatment problems like excessive force or wrong force direction that jeopardizes occlusion or health of teeth/tissues. Fractured/loose wires, loose bands, torn rubbers, and sharp components that injure tissues. Manage by adjustment or replacement of the component without aerosol generation. 	<ul style="list-style-type: none"> Postpone orthodontic treatments until the patient is COVID-19 free.
Conservative dentistry	<ul style="list-style-type: none"> Inhaled or swallowed fractured filling 	<ul style="list-style-type: none"> Carious lesions with persistent pain not responding to medication. Manage by application of silver diamine fluoride¹⁴⁸ or soft caries excavation with manual excavators and apply ozone on leathery caries,¹⁴⁹ then use temporary filling. Fissure sealant and fluoride application do not require aerosol production. 	<ul style="list-style-type: none"> Postpone restorations and fillings to avoid aerosol production via cavity drilling and tooth preparation using handpieces.

Flowchart 3: Flow diagram of recommendations for preparation and treatment of patients who demand dental care amid COVID-19 pandemic



Patients are advised to avoid using toilets unless necessary and should inform the staff before using clinic toilets. The toilets should be flushed while closed and should be disinfected before and after use.¹⁴³

Staff should be vigilant during cleaning and disinfection of clinic facilities and instruments, and should always wear thick or double surgical gloves, fluid-resistant surgical masks, and water-resistant full gowns. Use N95 or higher masks during cleaning after COVID-19 potential/confirmed patients, and be very careful throughout the process.

Discard all medical and hazardous waste (including PPE, clinic, and toilet waste) following local authorities' recommendations.^{41–49,93–102}

Staff Preparation

Staff who is confirmed/suspected to have COVID-19 or contacted/treated COVID-19 confirmed/potential patients should not treat patients, not attend the clinic, be reported to health authorities for assessment, and resume work only after confirmed



COVID-19 free. Confirmed/suspected COVID-19 patients should not be managed by staff at risk including pregnant and medically compromised care providers enduring immune problems, hypertension, diabetes, cardiovascular, pulmonary, kidney, or liver disease.¹⁴⁴

Regular staff testing is necessary particularly if treating COVID-19 potential/confirmed patients. Staff confirmed COVID-19 free, vaccinated, and/or with antibodies to SARS-CoV-2 virus are more practical to deal with COVID-19 confirmed/potential cases. Nevertheless, cross-infection control and extreme caution should be exerted all the time regardless of having antibodies to SARS-CoV-2.^{58–61} Staff working hours, financial pressure, workload, and mental wellbeing should be taken into consideration as they could potentially lead to distractions and violations of cross-infection protocols, disease spreading, and care disruption.^{150,151}

All dental staff should have proper training regarding cross-infection control, management protocols for COVID-19 potential/confirmed patients, and the use of PPE (donning and doffing).^{41–49,93–102} The balance between using four-handed dentistry, reduction of staff number, and utilizing consultation services allows effective shorter treatment sessions and reduces disease transmission.

Donning the PPE starts with the removal of jewelry, bracelets, rings, and other objects. Then, wash hands with soap (e.g., povidone iodine soap scrub) for 60 seconds followed by hand disinfection using 60–85% alcohol gel for 1 minute.^{41–49,93–102} Then in the following order, wear the first pair of surgical gloves, mask, goggles, head cap, face shield, water-repellent long-sleeved full gown, and shoe cover. Then, disinfect the gloved hands using 60–85% alcohol gel for 1 minute before wearing the second pair of surgical gloves. The preferred masks to use in descending order are PAPR, N100, N99 or FFP3, N95 or FFP2.^{107,110,111,122,132} The PAPR masks are to be used if N and FFP masks cannot be fit tested due to facial hair.^{107,111,122,132} Use a surgical mask over the N or FFP masks to allow multilayer doffing and reduce soiling the N or FFP mask.¹⁰⁷ Do not rely on surgical masks only or FFP1 masks as they are not adequate against COVID-19.^{107,111} Double check the PPE after donning to ensure adequate use and coverage by the PPE.

Doffing after treatment should be done carefully to prevent disease transmission. It should be done outside the treatment area to prevent contamination or infection due to airborne aerosols produced in the treatment area. Select an area just outside the treatment area and allocate it for doffing. This area should be dealt with high vigilance to prevent cross-infection. Then in the following order, start doffing by disinfecting the double-gloved hands using 60–85% alcohol gel for 1 minute then remove the gown, the outer pair of gloves, face shield/goggles, head cap, shoe cover, mask, and the inner gloves.^{41–49,93–102} Apply alcohol disinfectant on the gloved hands after removal of each piece of the PPE. Finally, wash hands with soap (e.g., povidone iodine soap scrub) for 60 seconds followed by hand disinfection using 60–85% alcohol gel for 1 minute.^{41–49,93–102}

Disposable PPE is used for one patient only and discarded in a sealed plastic bag following local authorities' recommendations.^{41–49,93–102} Use 70% alcohol to disinfect reusable PPE items (e.g., goggles and face shields) or utilize ozone generating machines if present.^{41–49,93–102,145}

Handling and disinfection of reusable PPE items should be performed while wearing thick or double surgical gloves, water-repellent gowns, and surgical masks (higher masks if COVID-19 potential/confirmed patient).⁴⁷

Do not go home wearing clinic uniforms, clothes, and surgical scrubs.^{41–43,47,48,93,96–102} Wash them using laundry at site or professional outside laundry that deals with medical laundry. It is recommended to soak the clothes in disinfectants (e.g., sodium hypochlorite, mind the bleaching effects of used disinfectants) for 10 minutes before being washed alone in a half-loaded washing machine at the highest temperature tolerated by the cloths; e.g., 60°C for 30 minutes or 80–90°C for 10 minutes.⁴⁷

If the disease is spreading out of control, limit treatment to specialized dental hospitals that carry urgent/emergency treatments, apply strict cross-infection control, and have the facilities to manage COVID-19 potential/confirmed cases.

CONCLUSION

COVID-19 is changing the world including dental healthcare provision protocols and standards unless a cure is found or an evidenced-based resolution for dental aerosol is established. Creative thinking and new flexible dental techniques and settings should lead the change of dental practice to deal with the impacts of COVID-19 on dentistry. Nevertheless, immediate guidelines and standard protocols should be implemented to overcome the limitations and disruptions caused by the outbreaks of COVID-19 and thus offer dental care to all patients not merely for emergency reasons.

The current manuscript provides recommendations, guidelines, and standards applied during the outbreaks of COVID-19 in many countries around the world based on available research and clinical experience and practice including those of the authors.

This could be part of the search to identify the golden standards for the provision of dental care during the existing difficult conditions.

It is important to recognize that some available recommendations were not tested via evidence-based research due to the rapid and unexpected occurrence of COVID-19 that overwhelmed health systems. The nature of the disease and the lack of definitive cure limit the ability to conduct clinical research within dental settings. The rapid, extensive, and changing flow of information regarding this pandemic add further challenges to provide evidence-based research in this regard. Therefore, clinical experiences of researchers and dental professionals, as well as opinions of dental authorities, panels, and respected dental scientists are crucial sources for information and guidelines for dental care provision during the current outbreaks of COVID-19.

Currently, different areas of the world are witnessing new waves of COVID-19 outbreaks with increased numbers of infected cases which might lead to prolonged disruption of dental care. Therefore, future evidence-based studies are necessary to find the golden standards for dental care provision in the current situations and to investigate innovative initiatives and methods that could potentially transform the present dental practice that we are familiar with.

ACKNOWLEDGMENTS

The authors thank Mrs. AbdelAziz M. for her help during the preparation of this manuscript. Thanks also to the University of Jordan, King Khalid University, and Jouf University for preparing this manuscript possible and for providing administrative support.

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