Concise Review

The Provision of Dental Care to COVID-19 Survivors: A Concise Review

Wei Cheong Ngeow, Liszen Tang*, Jan Yang Ho, Hui Wen Tay, Raymond Chung Wen Wong, Mas Suryalis Ahmad, Vinay Marlaf, Karthick Sekara

Aims: It has been reported that there are a certain percentage of COVID-19 patients who recover but suffer from devastating permanent organ damage or failure. Others suffer from long Covid syndrome, with prolonged symptoms that persist more than 12 weeks. However, there is scarcity of literature regarding the provision of dental treatment for these two groups of patients. This manuscript reviews the impact of multi-system involvement on the provision of dental care to these patients.

Materials and methods: A search of literature was done in PubMed-Medline and Scopus databases to review the available literature on COVID-19 impacts on pulmonary, cardiovascular, haematologic, renal, gastrointestinal, endocrine, and neurologic systems and respective management in dental clinical settings.

Results: The literature search from PubMed-Medline and Scopus databases resulted in 74 salient articles that contributed to the concise review on COVID-19 effects on pulmonary, cardiovascular, haematologic, renal, gastrointestinal, endocrine, and neurologic systems and/or its respective dental management recommendations.

Conclusions: This concise review covers the management of post COVID-19 patients with pulmonary, cardiovascular, haematologic, renal, gastrointestinal, endocrine, or neurologic system complications.

Introduction

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is transmitted via air droplets, with clinical manifestations that range from asymptomatic to multiorgan system dysfunction. The multisystemic nature of the disease is related to the tropism of the virus for the angiotensin-converting enzyme 2 (ACE-2) receptors in several organs. The highest levels of SARS-CoV-2 copies are detected in the respiratory tract, with lower levels detected in the kidney, liver, heart, brain, and blood. Multisystem involvement in COVID-19 infection can range from mild to severe devastating permanent organ damage or failure (Figure 1). Patients are defined as postacute COVID-19 patients if they present with persistent symptoms and/or long-term complications of SARS-CoV-2 infection beyond 4 weeks from the onset of symptoms. They can be further divided into subacute or ongoing symptomatic (4−12 weeks) and chronic or post-COVID-19 syndrome (>12 weeks).

Current management against COVID-19 includes vaccination and/or treatment of systemic symptoms. Alharbi et al in their proposed guideline of dental care provision stated that convalescent recovered patients should be considered as potential SARS-CoV-2 carriers for at least 30 days after
laboratory test confirmation of recovery. Some of them have been reported to experience persistent immune suppression and altered cholesterol metabolism, blood coagulation, and cardiomyopathy, which appear to be a prelude to long COVID.

COVID-19 survivors have been reported to manifest up to 200 symptoms. A cohort study found that oral manifestations after recovery are not uncommon. They include salivary gland ectasia (38%), xerostomia (30%), masticatory muscle weakness (19%), loss of taste and smell (10%), and temporomandibular joint abnormalities (7%).

Currently, one report highlighting the management of dental care in COVID-19 survivors suggested monitoring oxygen saturation, heart rate, and blood pressure as part of their routine examination during dental treatment. A physical performance test and psychologic screening may be performed when applicable. Chakraborty et al suggested that future research should be done on the effects of thromboprophylaxis in dental treatment and the safe administration of perioperative antibiotics and analgesics in COVID-19 survivors. The current concise review tries to address these issues as well as other medical complications during the dental treatment of these patients.

Methods

A literature search was done in PubMed-MEDLINE and Scopus databases using the keywords “SARS-CoV-2,” “COVID-19,” “severe acute respiratory syndrome,” “dental management,” “pulmonary,” “cardiovascular,” “neurological,” “renal,” “gastrointestinal,” “endocrine,” “haematological,” “COVID-19 vaccine,” “COVID-19 vaccine booster,” “unvaccinated,” and “anti-vaccinated” to identify the literature published in English between January 2000 and March 2022 (Table 1). This concise review aims to identify the relevant dental management of post-COVID-19 patients or patients with long COVID syndrome from currently available published studies. The inclusion criteria are articles of clinical studies such as randomised control studies, cohort studies, and multicentre studies as well as systematic review and meta-analysis due to the high level of evidence. Relevant systemic guidelines and position papers were also included, and the recommendations are extrapolated to dental care where applicable. All the obtained abstracts of titles were screened independently to remove irrelevant articles by 7 authors. The exclusion criteria are those articles of opinion, perspective, commentary, editorial, communication, case report, case series, non-English-
language, no full text, and of irrelevant information. Then the collected article abstracts and full texts were critically reviewed. The discrepancies amongst 7 authors would be resolved by iteration. An independent reviewer (first author) who was blinded to other reviewers’ assessment resolved unreconciled discrepancies. The risk of bias assessment was done on all the included articles using methodological quality assessment by combining the proposed criteria of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement,8 Risk of Bias in Systematic Reviews (ROBIS),7 and the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.10

Results

A total of 5588 studies were retrieved from the PubMed-MEDLINE and Scopus databases, and 1 was from a manual search in printed material. After undergoing screening and eligibility phases, a total of 74 articles were included in the review; 387 articles were excluded at the full-text stage, with classification of the types and focuses of studies as illustrated in Figure 2. The different risk of bias level of all included articles are illustrated in Table 2 and Table 3.

Discussion

There is still a lacunae in terms of managing post-COVID-19 dental patients. Balaji highlighted that many of these patients are treated with long-term medications that interact with dentistry-related medications.11 He emphasised the need to include history of COVID-19 infection and its residual impact, that dentists might face and came up with several dental care. Chakraborty et al also highlighted the possible impact of COVID-19 infection and its residual impact, as they might exacerbate chronic obstructive pulmonary disease after COVID-19 infection.28 It is also best to avoid prescribing nonsteroidal anti-inflammatory drugs (NSAIDs) to the recovered COVID-19 patient with asthma to prevent severe bronchospasm.

Effect of COVID-19 on the central nervous system and how it impacts dental management

There is growing evidence on neurologic complications, which occur more commonly in elderly individuals or people with comorbidities.3 Non-specific mild neurologic symptoms include headache (8%–42%), dizziness (12%), anorexia (40%), myalgia and/or fatigue (11%–44%), anosmia (5%), and hypogeusia or ageusia (5%).31–34 The most prevalent neurologic signs were acute encephalopathy (49%) presenting as altered mental status, abnormal speech (5%) or motor movement (3%), impaired consciousness or coma (17%), and stroke (6%).34 Treatment for COVID-19 patients with stroke include the administration of anticoagulants such as low-molecular-weight heparin or unfractionated heparin.35,36 For patients who survived the infection, oral anticoagulants are sometimes continued due to prothrombotic state.37,38 Routine or elective dental procedures are best deferred to 6 months after the incident of cerebrovascular accident. Special precautions with local haemostatic measures including the placement of local haemostatic agents, suturing, gauze compression, and a
prescription of mouthwash 5% tranexamic acid should be undertaken especially for invasive dental procedures. NSAIDS should be avoided in pain management to reduce the risk of bleeding.

Bell’s palsy is increasingly being reported as a possible neurologic complication of COVID-19 and its vaccination.39 Patients with Bell’s palsy are usually started on a 10-day course of corticosteroids.40,41 They would not require corticosteroid supplement before dental procedures due to the short course of corticosteroid therapy.

Some patients might present with persistent autonomic nervous system dysfunction, known as postural orthostatic tachycardia syndrome (POTS). They may complain of palpitations and dizziness, especially upon abrupt standing from a dental chair, or fatigue or blurred vision.42 Neurocardiogenic syncope is a situation in which patients experience loss of consciousness with abrupt blood pressure and heart rate reductions during standing.43 Dentists should be fully equipped with the basic algorithm of: position (P), airway (A), breathing (B), circulation (C), and definitive treatment/differential diagnosis/drugs/defibrillation (D), in managing such emergency. As patients with POTS may also be prescribed a low-dose beta blocker, dentists have to look out for gingival hyperplasia, which may follow.8

Fig. 2 – Flowchart of search strategy outcomes.
| Article                                      | Year | Study type          | Theme/focus of the paper                                                                 | Random selection in population | Defined inclusion/exclusion criteria | Loss to follow-up reported | Validated measurement | Statistical analysis | Estimated potential risk of bias |
|---------------------------------------------|------|---------------------|------------------------------------------------------------------------------------------|---------------------------------|-------------------------------------|---------------------------|----------------------|---------------------|-----------------------|
| Nalbandian A et al                          | 2021 | Narrative review    | General systemic impact of post COVID-19 syndrome                                         | No                              | No                                  | No                        | No                   | No                  | High                  |
| Chakraborty T et al                         | 2021 | Narrative review    | General systemic dental management on post-COVID-19                                     | No                              | Yes                                 | No                        | Yes                  | No                  | High                  |
| Zhao Y-M et al                              | 2020 | Retrospective multi-centre cohort study | Post-COVID-19 respiratory system                                                        | No                              | Yes                                 | Yes                      | Yes                  | No                  | Moderate              |
| Sonnweber T et al                           | 2021 | Prospective cohort study | Post-COVID-19 respiratory system                                                         | No                              | Yes                                 | Yes                      | Yes                  | No                  | Moderate              |
| Blomberg B et al                            | 2021 | Prospective cohort study | Post-COVID-19 respiratory system                                                         | No                              | Yes                                 | Yes                      | Yes                  | No                  | Moderate              |
| Yang L-L et al                              | 2020 | Narrative review    | Post-COVID-19 respiratory rehabilitation                                                  | No                              | No                                  | No                       | No                   | No                  | High                  |
| Carvalho AC et al                           | 2021 | Randomised controlled trial | Post-COVID-19 respiratory rehabilitation                                                 | Yes                             | Yes                                 | Yes                      | Yes                  | Yes                 | Low                   |
| Jevon P                                    | 2014 | Narrative review    | Emergency in dentistry                                                                   | No                              | No                                  | No                       | No                   | No                  | High                  |
| Devlin J                                   | 2014 | Narrative review    | Dental management for respiratory system                                                  | No                              | No                                  | No                       | No                   | No                  | High                  |
| O’Driscoll BR et al                         | 2017 | Guideline           | Respiratory emergency management                                                         | No                              | Yes                                 | No                       | Yes                  | Yes                 | High                  |
| Bolaki M et al                              | 2020 | Narrative review    | COVID-19 respiratory management                                                          | No                              | No                                  | No                       | No                   | No                  | High                  |
| Claramunt Lozano A et al                   | 2011 | Narrative review    | Dental management for respiratory system                                                  | No                              | Yes                                 | No                       | Yes                  | No                  | High                  |
| Leung JM et al                              | 2020 | Narrative review    | COVID-19 and respiratory system                                                          | No                              | Yes                                 | No                       | Yes                  | No                  | High                  |
| Lee SC et al                                | 2021 | Retrospective cohort study | COVID-19 and respiratory system                                                         | No                              | Yes                                 | Yes                      | Yes                  | Yes                 | moderate              |
| Huang C et al                               | 2020 | Prospective cohort study | COVID-19 impact on the general system                                                     | No                              | Yes                                 | Yes                      | Yes                  | Yes                 | Moderate              |
| Chen N et al                                | 2020 | Retrospective descriptive study | COVID-19 impact on the general system                                                     | No                              | Yes                                 | Yes                      | Yes                  | Yes                 | Moderate              |
| Klopfenstein T et al                       | 2020 | Retrospective observational study | COVID-19 impact on the neurologic system                                                   | No                              | Yes                                 | No                       | Yes                  | Yes                 | Moderate              |
| Chou SH-V et al                             | 2021 | Multicohort observational study | COVID-19 impact on the neurologic system                                                  | No                              | Yes                                 | No                       | Yes                  | Yes                 | Moderate              |
| Gupta A et al                               | 2020 | Review article      | COVID-19 impact on the general system                                                      | No                              | No                                  | No                       | No                   | No                  | High                  |
| Tang N et al                                | 2020 | Retrospective cohort study | COVID-19–related coagulopathy and its management                                           | No                              | No                                  | Yes                      | Yes                  | Yes                 | High                  |

(continued on next page)
| Article                | Year | Study type            | Theme/focus of the paper                                                                 | Random selection in population | Defined inclusion/exclusion criteria | Loss to follow-up reported | Validated measurement | Statistical analysis | Estimated potential risk of bias |
|-----------------------|------|-----------------------|-----------------------------------------------------------------------------------------|--------------------------------|-------------------------------------|---------------------------|----------------------|---------------------|-----------------------------|
| Paranjpe I et al      | 2020 | Retrospective Cohort study | COVID-19–related coagulopathy and its management                                           | No                             | No                                  | No                        | Yes                  | Yes                 | High                        |
| McCaul JA et al       | 2014 | Review article        | Bell’s palsy management (non-COVID-19–related)                                            | No                             | No                                  | No                        | No                   | No                  | High                        |
| Baugh RF et al        | 2013 | Clinical practice guideline | Bell’s palsy clinical practice guideline                                                   | No                             | No                                  | No                        | No                   | No                  | High                        |
| Thieben MJ et al      | 2007 | Retrospective cross-sectional study | Postural orthostatic tachycardia syndrome and its management (non-COVID-19–related)      | No                             | Yes                                 | No                        | Yes                  | Yes                 | High                        |
| Raj SR et al          | 2020 | Position statement    | Position statement on postural orthostatic tachycardia syndrome and its management (non-COVID-19–related) | No                             | No                                  | No                        | No                   | No                  | High                        |
| Moldofsky H et al     | 2020 | Retrospective case-control study | Post-COVID-19 infection impact on mental health/psychology                              | No                             | No                                  | Yes                       | Yes                  | Yes                 | High                        |
| Madjid M et al        | 2020 | Narrative review      | COVID-19 impact on cardiovascular system                                                  | No                             | No                                  | No                        | No                   | No                  | High                        |
| Polito MV et al       | 2021 | Narrative review      | Sequelae of COVID-19 on cardiovascular system                                              | No                             | No                                  | No                        | No                   | No                  | High                        |
| Visco V et al         | 2022 | Narrative review      | COVID-19 impact on multiple systems symptoms after COVID-19                                 | No                             | No                                  | No                        | No                   | No                  | High                        |
| Caspersen IH et al    | 2022 | Narrative review      | Sequelae of COVID-19 on cardiovascular system                                              | No                             | No                                  | No                        | No                   | No                  | High                        |
| Raman B et al         | 2022 | Narrative review      | Sequelae of COVID-19 on cardiovascular system                                              | No                             | No                                  | No                        | No                   | No                  | High                        |
| Wu L et al            | 2022 | Narrative review      | Symptoms after COVID-19 amongst hospitalized patients                                      | No                             | No                                  | No                        | No                   | No                  | High                        |
| Akbari A et al        | 2022 | Narrative review      | Symptoms requiring readmission post-COVID-19                                              | No                             | No                                  | No                        | No                   | No                  | High                        |
| Joshee S et al        | 2022 | Narrative review      | Long-term effects of COVID-19                                                               | No                             | No                                  | No                        | No                   | No                  | High                        |
| Sanyaolu A et al      | 2022 | Narrative review      | Sequelae of COVID-19 on multiple systems                                                   | No                             | No                                  | No                        | No                   | No                  | High                        |
| Elseidy SA et al      | 2022 | Narrative review      | Sequelae of COVID-19 on cardiovascular system                                              | No                             | No                                  | No                        | No                   | No                  | High                        |
| Wright C             | 2019 | Clinical practice guideline | Practice guideline on patient management                                                   | No                             | No                                  | No                        | No                   | No                  | High                        |
| Article                  | Year | Study type                    | Theme/focus of the paper                               | Random selection in population | Defined inclusion/exclusion criteria | Loss to follow-up reported | Validated measurement | Statistical analysis | Estimated potential risk of bias |
|-------------------------|------|-------------------------------|-------------------------------------------------------|--------------------------------|-------------------------------------|---------------------------|------------------------|----------------------|-------------------------|
| Cheung CKM et al58      | 2021 | Narrative review              | Haematology and COVID-19                              | No                             | No                                  | No                        | No                     | No                   | High                    |
| Garcia de Guadiana-     | 2021 | Prospective observational     | Haematology and COVID-19                              | No                             | Yes                                 | No                        | No                     | No                   | Moderate                |
| Romualdo L et al60      | 2020 | Narrative review              | Haematology and COVID-19                              | No                             | No                                  | No                        | No                     | No                   | High                    |
| Leticia de Oliveira     | 2020 | Narrative review              | Haematology and COVID-19                              | No                             | No                                  | No                        | No                     | No                   | High                    |
| Toledo S et al61        | 2020 | Narrative review              | Haematology and COVID-19                              | No                             | No                                  | No                        | No                     | No                   | High                    |
| Terpos E et al81        | 2020 | Retrospective cohort study    | COVID-19 impact on the renal system                  | No                             | No                                  | No                        | No                     | No                   | High                    |
| Abdallah E et al65      | 2020 | Retrospective cohort study    | COVID-19 impact on the renal system                  | No                             | No                                  | No                        | No                     | No                   | High                    |
| Arikan H et al66        | 2021 | Retrospective observational   | COVID-19 impact on the renal system                  | No                             | Yes                                 | No                        | Yes                    | Yes                  | High                    |
| Bowe B et al18          | 2021 | Narrative review              | Haematology and COVID-19                              | No                             | No                                  | No                        | No                     | No                   | High                    |
| Chan L et al84          | 2020 | Retrospective observational   | COVID-19 impact on the renal system                  | No                             | Yes                                 | No                        | Yes                    | Yes                  | High                    |
| Almeida DC De et al85   | 2021 | Retrospective cohort study    | COVID-19 impact on the renal system                  | No                             | No                                  | No                        | No                     | No                   | High                    |
| Yu Y et al85            | 2021 | Retrospective cohort study    | COVID-19 impact on the renal system                  | No                             | Yes                                 | No                        | Yes                    | Yes                  | High                    |
| D’Amico F et al82       | 2020 | Retrospective cohort study    | COVID-19 and gastrointestinal manifestations          | No                             | No                                  | No                        | No                     | No                   | High                    |
| Zhong P et al93         | 2021 | Narrative review              | Haematology and COVID-19                              | No                             | No                                  | No                        | No                     | No                   | High                    |
| Marazuela M et al94     | 2020 | Narrative review              | Haematology and COVID-19                              | No                             | No                                  | No                        | No                     | No                   | High                    |
| Scappaticcio Let95      | 2020 | Narrative review              | Haematology and COVID-19                              | No                             | No                                  | No                        | No                     | No                   | High                    |
| Guan WJ et al96         | 2020 | Retrospective observational   | COVID-19 and general systemic manifestations          | No                             | Yes                                 | No                        | Yes                    | Yes                  | High                    |
| Richardson S et al97    | 2020 | Retrospective observational   | COVID-19 and general systemic manifestations          | No                             | Yes                                 | No                        | Yes                    | Yes                  | High                    |
| Petrilli CM et al101    | 2020 | Retrospective observational   | COVID-19 and general systemic manifestations          | No                             | Yes                                 | No                        | Yes                    | Yes                  | High                    |
| Hernandez-Galdamez DR et al109 | 2020 | Retrospective observational   | COVID-19 and general systemic manifestations          | No                             | Yes                                 | No                        | Yes                    | Yes                  | High                    |
| Muniyappa R et al110    | 2020 | Narrative review              | COVID-19 and endocrine system                         | No                             | No                                  | No                        | No                     | No                   | High                    |
| Pal R & Bannerjee M.111  | 2020 | Narrative review              | COVID-19 and endocrine system                         | No                             | No                                  | No                        | No                     | No                   | High                    |
| Liu F et al112          | 2020 | Retrospective observational   | COVID-19 and endocrine system                         | No                             | Yes                                 | No                        | Yes                    | Yes                  | High                    |
| Chatterjee S et al113   | 2020 | Retrospective review         | COVID-19 and endocrine system                         | No                             | No                                  | No                        | No                     | No                   | High                    |
| Bhandari S et al114     | 2020 | Retrospective observational   | COVID-19 and endocrine system                         | No                             | Yes                                 | No                        | Yes                    | Yes                  | High                    |

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Table 2 (Continued)

| Article | Year | Study type          | Theme/focus of the paper                                                                 | Random selection in population | Defined inclusion/exclusion criteria | Loss to follow-up reported | Validated measurement | Statistical analysis | Estimated potential risk of bias |
|---------|------|---------------------|----------------------------------------------------------------------------------------|-------------------------------|-------------------------------------|---------------------------|----------------------|---------------------|-----------------------------|
| Pfutzner A et al<sup>15</sup> | 2020 | Narrative review    | COVID-19 and endocrine system with dental manifestations                               | No                            | No                                  | No                        | No                   | No                  | High                        |
| Miller A & Ouanounou A.<sup>16</sup> | 2020 | Narrative review    | Dental management associated with endocrine disorders                                   | No                            | No                                  | No                        | No                   | No                  | High                        |
| Vernillo AT<sup>17</sup> | 2003 | Narrative review    | Dental management associated with endocrine disorders                                   | No                            | No                                  | No                        | No                   | No                  | High                        |
| Yang LC et al<sup>18</sup> | 2020 | Prospective observational study | Dental management associated with respiratory disorders                               | Yes                           | Yes                                 | No                        | Yes                  | Yes                 | Moderate                    |

Table 3 – Risk of bias assessment of the included systematic review and meta-analysis.

| Author                  | Study type                        | Theme/focus of the article       | Study eligibility criteria | Identification and selection of studies | Data collection and study appraisal | Synthesis and findings | Potential risk of bias |
|-------------------------|-----------------------------------|----------------------------------|----------------------------|----------------------------------------|-----------------------------------|------------------------|------------------------|
| Gerayeli FV et al<sup>19</sup> | Systematic review and meta-analysis | COVID-19 and respiratory system | Yes                       | Yes                                   | Yes                               | Yes                    | Low                    |
| Tan YK et al<sup>20</sup> | Systematic review and meta-analysis | COVID-19 and acute ischemic stroke | Yes                       | Yes                                   | Yes                               | Yes                    | Low                    |
| Gupta S et al<sup>21</sup> | Systematic review                 | Bell’s palsy as the only neurologic presentation of COVID-19 | Yes                       | Yes                                   | Yes                               | Yes                    | Low                    |
| Bajwa H et al<sup>22</sup> | Systematic review                 | Renal involvement in COVID-19    | No                        | No                                     | No                                | No                     | High                   |
| Fu EL et al<sup>23</sup> | Systematic review and meta-analysis | Renal involvement in COVID-19    | No                        | No                                     | No                                | Yes                    | High                   |
| Kunutsor SK et al<sup>24</sup> | Systematic review and meta-analysis | Renal involvement in COVID-19    | Yes                       | No                                     | No                                | Yes                    | High                   |
| Cheung KS et al<sup>25</sup> | Cohort Study and systematic review/metanalysis | COVID-19 and gastrointestinal system | Yes                       | Yes                                   | Yes                               | Yes                    | Low                    |
| Wang J gan et al<sup>26</sup> | Systematic review/metanalysis      | COVID-19 and gastrointestinal system | Yes                       | Yes                                   | Yes                               | Yes                    | Low                    |
that dental treatment is undertaken in a safe manner, and arrhythmias,47 include hypotension, tachycardia, palpitations, dyspnoea, hygiene maintenance. and patients’ caregivers should diligently provide oral instructions following dental treatment. Hence, the dentists may neglect good oral hygiene or lack the ability to follow readmission. 51 There are increased risks of incident and autonomic dysfunction, as in POTS.6 Increased cardio-myocardial fibrosis or scarring, arrhythmias, tachycardia, sequelae may include increased cardiometabolic demand, the renin cardiac reserve, corticosteroid use, and dysregulation of metabolic demand may be associated with reduced malignant arrythmia.46 Persistent symptoms may temic inflammation may lead to ventricular dysfunction close monitoring, even after discharge, as the ongoing systemic inflammatory response induces endothelitis, 59 but it is not clear how long endotheliitis can persist in the convalescent phase. Laboratory tests confirmed that patients with elevated D-dimer (≥0.5 mg/L) and presenting with bacteraemia. 52 Initial evaluation with noninvasive technology (such as electrocardiography, echocardiography, laboratory testing for C-reactive protein and troponin) is recommended. 54 Cardiac emergency episodes that may occur in patients during dental treatment include syncope (see POTS in the neurologic complication section), coronary ischaemic syndrome, and cardiac arrest. 57 Precautionary measures to prevent cardiac emergency events include assessment and monitoring of vital signs during procedures, as recommended by Chakraborty et al,7 as well as the delivery of adequate pain control and stress-reduction measures. 57

**Effect of COVID-19 on the cardiovascular system and how it impacts dental management**

Cardiac injury may develop in COVID-19 patients with or without an existing cardiovascular disease. 45 They need close monitoring, even after discharge, as the ongoing systemic inflammation may lead to ventricular dysfunction and malignant arrhythmia. 56 Persistent symptoms may include hypotension, tachycardia, palpitations, dyspnoea, and arrhythmias,47−50 with some patients requiring hospital readmission. 51 There are increased risks of incident cardiovascular disease, such as cerebrovascular disorders (stroke/transient ischaemic attacks), dysrhythmia (atrial fibrillation/sinus tachycardia), ischaemic heart disease (acute coronary disease/myocardial infarction/angina), thromboembolic disease (pulmonary embolism/deep vein thrombosis), heart failure, pericarditis, myocarditis, cardiac arrest, and cardiogenic shock. 49,52−56 Long-term sequelae may include increased cardiometabolic demand, myocardial fibrosis or scarring, arrhythmias, tachycardia, and autonomic dysfunction, as in POTS.6 Increased cardiometabolic demand may be associated with reduced cardiac reserve, corticosteroid use, and dysregulation of the renin–angiotensin–aldosterone system.

Consultation with the cardiology team is vital to ensure that dental treatment is undertaken in a safe manner, considering the risk of cardiac emergency episodes and bacteraemia. 52 Initial evaluation with noninvasive technology (such as electrocardiography, echocardiography, laboratory testing for C-reactive protein and troponin) is recommended. 54 Cardiac emergency episodes that may occur in patients during dental treatment include syncope (see POTS in the neurologic complication section), coronary ischaemic syndrome, and cardiac arrest. 57 Precautionary measures to prevent cardiac emergency events include assessment and monitoring of vital signs during procedures, as recommended by Chakraborty et al,7 as well as the delivery of adequate pain control and stress-reduction measures. 57

**Effect of COVID-19 on the haematologic system and how it impacts dental management**

Thromboembolic events that include segmental pulmonary embolism, intracardiac thrombus, thrombosed arteriovenous fistula, and ischaemic stroke have been noted in less than 5% of COVID-19 survivors. 58 This COVID-19–associated coagulopathy is consistent with patients’ hyperinflammatory and hypercoagulable state. 6 The hyperinflammatory response induces endothelitis, 59 but it is not clear how long endothelitis can persist in the convalescent phase. Laboratory tests confirmed that patients with elevated D-dimer (≥0.5 mg/L) and presenting with cardiac injury (see cardiovascular complication section) are more prone to coagulation disorders. 57 Because of the risk of venous thromboembolism in hospitalised COVID–19 patients lasts up to 90 days following discharge, they receive pharmacologic thromboprophylaxis with low-molecular-weight heparin (LMWH) over unfractionated heparin, unless the risk of bleeding outweighs the risk of thrombosis. 61
Direct oral anticoagulants and LMWH are sometimes considered for extended thromboprophylaxis in selected cohorts of “risky” patients. Thus, dentists are not expected to manage the haemostasis effect of this drug in the dental office. However, the impact of extended thromboprophylaxis on dental surgical procedures shall be borne in mind with their management similar to that described under the neurologic complication section.

Regular monitoring of blood results and evaluation of the individualised thrombotic risk based on comorbidities and coagulation profile are essential for both postacute and long COVID to provide a tailored therapeutic application. Invasive dental procedures should be deferred if the patient is deemed to be at high risk.

**Effect of COVID-19 on the renal system and how it impacts dental management**

Kidney involvement is not uncommon in COVID-19. Renal complications encountered include proteinuria, haematuria, electrolyte disturbances, reduced glomerular filtration rate (GFR) and, more significantly, acute kidney injury (AKI). AKI is associated with a higher mortality rate, with intensive care unit admission and the need for mechanical ventilation. The incidence of AKI is variable, ranging between 4.2% and 71.2%. Two recent systematic reviews reported a pooled incidence rate of 6% and 11%, respectively, with subgroup analysis indicating that the US population experienced more cases than the Chinese population.

Dentists treating patients recovered from COVID-19 need to be aware that there may be residual renal dysfunction; serum creatinine remained elevated for 47% of COVID-19 patients upon hospital discharge. In a multicentre observational study, partial recovery from renal deterioration was observed in 17.2% of patients, and this finding was more common amongst patients with preexisting chronic kidney disease. Postacute sequelae were further corroborated by the observation that COVID-19 survivors had greater longitudinal estimated GFR reduction than noninfected controls.

Compromised renal function can predispose to infection; hence, any orofacial infection must be managed promptly by the removal of the infection source, supplemented with culture and sensitivity testing and appropriate antibiotic prescription as needed. There was no evidence, however, advocating the use of a prophylactic antibiotic to prevent infective endocarditis or endarteritis involving vascular access in patients undergoing hemodialysis.

For patients receiving renal replacement therapy, a few issues must be taken into consideration. Due to concomitant use of antiplatelet/anticoagulant medications and, to a lesser extent, uraemia-induced bleeding disorder, there is a greater risk of bleeding tendencies during and following invasive dental procedures. The dentist should perform coagulation screening prior to dental extractions. Antiplatelet/anticoagulant should not be altered without explicit instructions by the patient’s physician or nephrologist. Any elective treatment should be scheduled on a nondialysis day. Local haemostatic agents should be made available and used during invasive dental procedures.

As mentioned earlier, AKI superimposed on COVID-19 survivors with concomitant chronic kidney disease entailed greater risk of residual renal impairment. When renal function tests show severe impairment (GFR < 50 mL/min), elective dental care should be postponed. Any urgent dental treatment should be carried out in a hospital setting after consultation with the patient’s nephrologist and with constant monitoring of patient’s creatinine and urine output. When GFR decreases to below 50 mL/min, drug toxicity becomes a major concern. In such cases, either drug dosage is reduced or the interval between administrations is prolonged. Nephrotoxic drugs such as aspirin, NSAIDs, acyclovir, aminoglycosides, amphotericin, sedatives, muscle relaxants, and tetracycline should be avoided. When opioids such as morphine, codeine, tramadol, meperidine, and propoxyphene are used, either reduction in dosage or increase in dose interval are required. Acetaminophen (paracetamol) is generally safe due to primary hepatic metabolism. However, the kidneys contribute to glucuronidation of acetaminophen as well. If GFR falls below 10 mL/min, the dosing interval of acetaminophen should be increased to every 8 hours. Antibiotics that are safer for this group of patients are penicillin and its derivatives, clindamycin, and cephalosporins. Long-term NSAID use at high doses could lead to renal damage and hypertension. Some NSAIDs that can be considered for patients with renal disease are sulindac, nabumetone, and etodolac because their effects on renal prostaglandins are not as profound. However, NSAIDs are strictly prohibited amongst predialysis and renal transplant patients.

Azithromycin, erythromycin, clindamycin, doxycycline, and penicillin V are some antibiotics that do not require dose adjustments due to their extensive hepatic metabolism and biliary excretion. For other antibiotics, either dosage or dose interval adjustments are needed once GFR decreases to below 50 mL/min, preferably after consulting with the patient’s physicians.

Local anaesthetic agents such as 2% lidocaine and 2% mepivacaine can be safely used if serum creatinine is less than 2 mg/dL. If possible, the dentists should limit the use of local anaesthesia to 2 carpules, which should be sufficient to achieve adequate anaesthesia for most dental procedures. The recommended dose adjustment for some commonly prescribed drugs in dentistry according to the patient’s GFR is summarised in Table 4.

**Effect of COVID-19 on the gastrointestinal system and impact on dental management**

Studies reported that up to 70.3% of patients demonstrated faecal viral RNA shedding even after negative respiratory specimens, with higher numbers in the paediatric population. Thus, the presence of diarrhoea in an otherwise asymptomatic person would warrant further investigation and raise a high index of suspicion. Such an inquiry shall be added to the medical history-taking of a dental patient.

SARS-CoV-2 infection can lead to liver injury, with facial skin darkening and increased pigmentation in some patients who recovered from severe COVID-19. The causes were ascribed to liver dysfunction causing increased melanin
production, adrenocortical hypofunction, or an increase in iron levels leading to a darkened face. COVID-19 patients with a darkened face may still continue viral shedding, and their dental case should be treated as non-urgent and elective and flagged.

Last, COVID-19 patients with digestive symptoms more commonly have prolonged prothrombin time (PT) than those with respiratory symptoms. The increased bleeding tendency with prolonged PT indicates the need for local measures for haemostasis following invasive dental procedures, as described earlier in the neurologic section. Last, hepatotoxic drugs such as acetaminophen should be reduced or avoided when a patient is diagnosed with liver injury. The expert advice of a gastroenterologist must be sought.

**Effect of COVID-19 on the endocrine system and how it impacts dental management**

The endocrine system can be affected significantly by COVID-19. It has been reported that patients with adrenal insufficiency, such as those with Addison’s disease and adrenal hyperplasia, are at higher risk for contracting COVID-19. Similarly, the effect of COVID-19 on the thyroid and the parathyroid glands has been highlighted, but with few documented cases so far.

Diabetes mellitus is considered an important risk factor associated with COVID-19. In addition, severe obesity with a body mass index (BMI) of over 40 kg/m², even in young patients, has been associated with increased morbidity and mortality. Some COVID-19 patients, there is increased expression of ACE-2 on the cells of the exocrine as well as islets of pancreas associated with elevated serum amylase/lipase levels suggestive of pancreatic injury. Another theory is related to the impairment of the immune system in patients with diabetes. Defective neutrophilic degranulation, phagocytosis, and complement activation have been suggested to be causative factors for viral infection. Thus, monitoring and maintaining the normal physiologic level of glucose is important.

Dental treatment of patients with diabetes during COVID-19 recovery remains unchanged, with emphasis on good oral hygiene maintenance. A thorough case history includes a review of the status of the course of medications, in-house glucose monitoring, and frequency of hypo- and hyperglycemic episodes. Fasting blood glucose values should range between 4.0 and 7.0 mmol/L, and a range of 5.0 to 10.0 mmol/L is considered acceptable postprandially. The patient should be monitored regularly to prevent the occurrence of any oral infection.

A study conducted in Taiwan had suggested that patients with diabetes had a higher risk of experiencing pneumonia,
but patients who received intensive periodontal treatment showed otherwise. This study highlighted that it is essential to control both the diabetic state as well as periodontal health to avoid serious complications of COVID-19.108

Other general management

It is generally acknowledged that COVID-19 is asymptomatic or milder in children and adolescents. Data on long COVID in children and adolescents are still scarce, with an estimated incidence of 5% to 10% due to heterogeneity of symptoms reported.109 Behnood et al identified 101 symptoms in children and young people.107 Their meta-regression showed that in adolescents, underlying comorbidities and female sex were associated with increased risk of persistent symptoms. Loss of smell, headaches, cognitive difficulties, and sore eyes and throat occurred between 2% and 8% more than the uninfected ones. There is no literature available regarding dental management in this group of patients; we recommend that dentists follow the recommendation for adults, with adjustment according to body weight when prescribing medications.

Vaccination (including booster) has been hailed as the way forwards for protecting both children and adults from the consequences of COVID-19. After COVID-19 vaccination, a 2-week period is usually required to mount adequate immunity against SARS-CoV-2. The dental health care professional should be aware of any systemic and/or orofacial adverse effects from vaccination. The presence of side effects such as headache, fever, or myalgia should be factored in when preparing a patient for dental procedures. Non-urgent procedures should be deferred where possible. Facial swelling from allergic reaction and Bell’s palsy have been reported,102 so these patients shall be referred accordingly. There is insufficient data to indicate whether the type of vaccine used should influence decision-making when planning dental treatment.

There is a segment of population who do not wish to receive vaccination or who are not fit to do so. The infectivity rate from unvaccinated individuals is estimated to be ~3 times higher compared to that of vaccinated individuals.103 It is thus important to put in place measures to protect them from cross-infection. These include optimal infection control practices, hand hygiene, adequate personal protective equipment, social distancing, and staggered schedules.

Breakthrough infection is defined as COVID-19 disease occurring in fully vaccinated individuals. They are generally milder or asymptomatic, although there is still the possibility for transmission. A recent study showed that the rate of breakthrough infection is extremely low (0.73%) and not associated with any comorbidities.104 In addition, one recent study reported that people who had been fully vaccinated against COVID-19 were around half as likely to experience long COVID symptoms.105 Nevertheless, non-urgent dental procedures must be deferred.

Last, there have been multiple variants being reported, including Omicron. Spike protein mutations can change the binding affinity to the ACE2 receptor for the vaccine-mediated antibody produced as well as for the virus variant. This favours reinfection and decreases the efficacy of vaccines.106 In addition, as the world is entering endemic stage, future infection is expected to continue, along with the long COVID issue. Thus, all suggestions described above may be applicable to future COVID-19 patients infected by different variants.

In summary, this concise review covers the treatment of patients with pulmonary, cardiovascular, haematologic, renal, gastrointestinal, endocrine, and neurologic system complications that result from COVID-19 infection. An algorithm that summarises the management of these patients is provided in Figure 3.

Author contributions

1. Ngeow WC: Conception, design, drafting, revising all the sections of the article, reviewing, and approving the final version to be published.
2. Tang L: Drafting, revising, referencing formatting, contributing to the “introduction” and “respiratory system” sections of the article, reviewing, and approving the final version to be published.
3. Ho JY: Drafting; revising; contributing to the figure, “introduction,” and “renal system” sections of the article; reviewing; and approving the final version to be published.
4. Tay HW: Drafting, revising, contributing to the figure and “central nervous system” sections of the article, reviewing, and approving the final version to be published.
5. Sekar K: Drafting, revising, contributing to the “haematologic system” section of the article, reviewing, and approving the final version to be published.
6. Ahmad MS: Drafting, revising, contributing the to tables and “cardiovascular system” section of the article, reviewing, and approving the final version to be published.
7. Wong RCW: Drafting, revising, contributing to the “gastrointestinal system” section of the article, reviewing, and approving the final version to be published.
8. Marla V: Drafting, revising, contributing to the “endocrine system” section of the article, reviewing, and approving the final version to be published.

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