



COVID-19: Current Knowledge and Best Practices for Orthopaedic Surgeons

Harvinder Singh Chhabra¹ · Vaibhav Bagaraia² · Swapnil Keny^{3,4} · Kalyan Kumar Varma Kalidindi⁵ · Abhinandan Mallepally⁵ · Mandeep Singh Dhillon⁶ · Rajesh Malhotra⁷ · Shanmuganathan Rajasekharan⁸

Received: 27 April 2020 / Accepted: 2 May 2020 / Published online: 18 May 2020
© Indian Orthopaedics Association 2020

Abstract

Background A mysterious cluster outbreak of pneumonia in Wuhan, China in December 2019 was traced to Severe Acute Respiratory Syndrome Coronavirus 2 and declared a Pandemic by WHO on 11th March 2020. The pandemic has spread rapidly causing widespread devastation globally.

Purpose This review provides a brief understanding of pathophysiology, clinical features, diagnosis and management of COVID-19 and highlights the current knowledge as well as best practices for orthopaedic surgeons. These are likely to change as knowledge and evidence is gained.

Results Orthopaedic surgeons, like other front-line workers, carry the risk of getting infected during their practice, which as such is already substantially affected. Implementation of infection prevention and control as well as other safety measures for health care workers assumes great importance. All patients/visitors and staff visiting the hospital should be screened. Conservative treatment should be the first line of treatment except for those requiring urgent/emergent care. During lockdown all elective surgeries are to be withheld. All attempts should be made to reduce hospital visits and telemedicine is to be encouraged. Inpatient management of COVID-19 patients requires approval from concerned authorities. All patients being admitted to the hospital in and around containment zones should be tested for COVID-19. There are special considerations for anaesthesia with preference for regional anaesthesia. A separate Operation room with specific workflow should be dedicated for COVID-19 positive cases.

Conclusions Despite the magnitude of challenge, the pandemic offers significant lessons for the orthopaedic surgeon who should seek the opportunity within the adversity and use this time wisely to achieve his/her Ikigai.

Keywords COVID-19 · SARS-CoV-2 · Orthopaedics · Outpatient · Surgical procedures · Operative · Guideline

Introduction

In December 2019, Wuhan, China, witnessed a mysterious cluster outbreak of pneumonia which on 31st of December 2019, was identified as a novel strain of coronavirus and termed by WHO as 2019-nCoV [1–3]. The International

Committee on Taxonomy of Viruses renamed it Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). The infection has continued its relentless march across the globe and was declared as a Public Health Emergency of International concern on the 30th of January 2020. It was named COVID-19 on the 11th of February 2020 and was declared as a global pandemic by WHO on March 11th 2020 [4, 5]. WHO announced the name of the disease as COVID-19 (Corona Virus Disease) on the 11th of February 2020 [4]. The outbreak was declared as a Public Health Emergency of International Concern on the 30th of January 2020 and later as a pandemic by WHO on the 11th of March 2020 [5].

The outbreak spread rapidly from China to many countries across the world. The epicentre of the pandemic continually shifted from Wuhan to Italy and then Spain in Europe and at present to New York State in the USA. The number

Mandeep Singh Dhillon, Rajesh Malhotra and Shanmuganathan Rajasekharan: multiple last authors.

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s43465-020-00135-1>) contains supplementary material, which is available to authorized users.

✉ Harvinder Singh Chhabra
issicon@isiconline.org

Extended author information available on the last page of the article

of confirmed COVID-19 cases in New York state has presently surpassed that of China's Hubei province, where the outbreak started. As of the 26th of April 2020, COVID-19 has affected 210 countries, infecting 2,995,056 individuals and claiming 207,000 lives [6].

Since the beginning of this outbreak, health care workers (HCW) working as frontline warriors have been recognized as a uniquely high-risk group [7]. Orthopaedic surgeons may not be in the front line in the fight against the viral pandemic, but the way they practice has been affected substantially [8]. It is likely to remain so for quite some time, and some changes would be here to stay. Some sub-specialties of Orthopaedic surgery like Arthroplasty, which deals with elderly with comorbidities, are affected more than Sports Medicine dealing with patients who are younger and healthy and require procedures which are often minimally invasive with a day care or short stay intervention.

Although orthopaedic surgeons face the risk of getting infected, especially from the substantial number of COVID-19 patients who are asymptomatic or in the incubation period, it is important to provide optimal management for orthopaedic diseases and also play a significant role in containing the pandemic.

This paper summarises the current knowledge about COVID-19 and provides recommendations for the diagnosis and treatment for orthopaedic diseases, especially emergencies during the course of the pandemic. It is pertinent to point out that since so little is known about this novel virus and the disease, this document cannot be considered as a dogma; guidelines will change as more evidence emerges. Readers are encouraged to keep up with the latest changing recommendations as they become available.

Pathophysiology and Disease Transmission

Available evidence suggests that SARS-CoV-2 primarily targets the pulmonary epithelial cells. The receptor-binding domain of SARS-CoV-2 spikes bind to the cellular receptor, angiotensin-converting enzyme 2 (ACE2), expressed abundantly in the alveolar epithelial cells [9]. As compared to the originally described SARS it has a 10–20 times higher affinity for the domain [10]. A cytokine storm is the reason behind acute lung injury, and hyperactivity of the complement system through the alternate pathway has been hypothesized as the possible mechanism. Preliminary reports employing complement inhibitors have shown promise, and randomized trials are under progress to test the efficacy of these drugs [11–13].

The incubation period of COVID-19 infection generally ranges from 3 to 7 days, upto a maximum of 14 days and rarely upto 24 days [14].

Since a large number of patients in Wuhan were exposed to the city's wet animal market, one school of thought suggests that COVID-19 is likely of zoonotic origin. Genomic sequence analysis of SARS-CoV-2 shows significant similarity to two bat-derived severe acute respiratory syndrome (SARS)-like coronaviruses, indicating that the disease may have originated from bats [15].

Human-to-human transmission occurs primarily through direct contact or through droplets spread by coughing or sneezing [14]. A recent study using a computer model to simulate the spread of SARS-CoV-2 suggested that the rapid increase of COVID-19 cases in China was mainly due to 'stealth transmissions' from undetected individuals with mild, limited, or no symptoms [16].

There is an ongoing debate regarding airborne transmission [17]. Viral RNA has been found on hard to reach surfaces and in air samples more than 2 m from patients in isolation rooms [18]. A study has reported that SARS-CoV-2 could float in aerosol droplets for up to 3 h and remain infectious, but the study used a high-powered nebulizer to generate aerosols, which does not simulate real-life situations of people coughing [19]. WHO has also opined that mere finding of the viral RNA does not imply a viable transmissible virus. Thus there is no sufficient evidence of airborne transmission, except in a few medical contexts, such as aerosol-generating procedures like intubation in an infected patient [20].

Recent evidence shows that the viral load, though low in feces from infected patients, can survive up to 2 days and raises the possibility of faecal–oral transmission [21]. Some researchers have pointed out that 8 COVID-19 patients who later became negative from nasopharyngeal swabs had still tested positive for the rectal swabs, emphasizing the need for testing rectal swabs before relieving them from quarantine as they may still be carriers [21].

Transmission could also occur through open ulcers or wounds. These should be kept covered through regular dressings following routine infection prevention and control measures [22].

Clinical Features

As per the Ministry of Health and Family Welfare, "8.61% cases in India are between 0 and 20 years, 41.88% between 21 and 40 years, 32.82% between 41 and 60 years and 16.69% above 60 years" as of April 4, 2020 [23]. The median age in India has been 39, whereas it has been 63 in Italy [23, 24]. This is in keeping with the demographic differences and possibly cohort testing differences between the two countries. The cases are also overwhelmingly males. The median age at death in India was 57, whereas in Italy, it was 80.

Patients generally present with fever, tiredness and/or dry cough. Other symptoms that some patients may have include aches and pains, nasal congestion, running nose, sore throat, diarrhea, or anosmia. A significant percentage of patients remain asymptomatic [2].

The onset is generally gradual. Up to 80% of patients have mild symptoms and recover without any special treatment. Approximately 14% develop severe disease requiring hospitalization and oxygen support and 5% require admission to an intensive care unit [25]. Severe cases can have complications like severe acute respiratory illness (SARI), sepsis, septic shock and multiorgan failure including acute kidney and cardiac injury [25, 26]. Heightened awareness of atypical COVID-19 presentations such as gastrointestinal symptoms (nausea, vomiting and diarrhea), ocular disturbances (conjunctivitis) and acute cardiac and neurological syndromes is essential to avoid missing diagnosis which may then lead to exponential spread of the virus [27].

Older people and those with comorbidities like diabetes, hypertension, respiratory/cardiac/kidney diseases are more at risk for severe disease and mortality [27, 28]. The mortality rate has varied from nation to nation. While the WHO estimated an average mortality rate of 3.4% globally, at the time of writing this article, amongst 18 countries that crossed 14,000 cases, the case fatality rate was highest in the Netherlands (9.4%) and lowest in Germany (0.3%). India, with a 3.2% case fatality, stood at ninth amongst these 18 nations [29].

Diagnosis

In the early stages, total leucocyte and lymphocyte counts are normal or decreased [30]. Erythrocyte sedimentation rate and C reactive protein are generally increased. CT Scan of Chest typically reveals multiple ground-glass opacities [31].

CDC recommends a real-time reverse transcription polymerase chain reaction (rRT-PCR) test for initial screening, which confirms the presence of SARS-CoV-2 by detecting its RNA [31]. The test is used to confirm very recent

or active infections. The sample is collected from a nasopharyngeal swab or sputum sample [32].

SARS-CoV-2 is not typically present in blood. However, antibody testing (serology) can be used both for diagnosis and population surveillance. Antibody tests are used to find out who has had the disease, even if asymptomatic or with minor symptoms [33].

Different countries have adopted different protocols for testing. Some countries like Germany have gone in for aggressive antibody testing of all symptomatic individuals as well as contacts for diagnosis and surveillance and rRT-PCR for confirmation. While South Korea and Singapore have been aggressive with rRT-PCR testing, others have restricted testing to symptomatic individuals with travel or contact history, symptomatic health care workers, those with SARI and asymptomatic direct or high-risk contacts [34]. However, these protocols also depend on which stage of the pandemic the region is in, and hence the protocols adopted by countries keep changing.

The Indian government's strategy of testing as on the 9th of April is given in Table 1 [35]. Information about location of testing centers in various states of India is available online [36].

COVID-19 Management Principles

The aim should be prevention, early detection, isolation, early supportive therapy, prevention/monitoring/aggressive management of severe clinical syndromes like severe pneumonia, SARI, sepsis as well as a septic shock; and prevention/early detection as well as management of complications associated with a critical illness. No specific treatment is available as of date. Lopinavir/Ritonavir/Ramdesivir has been used in some specific severe cases [37, 38]. The initial results of therapeutic plasma exchange have also been found to be promising [39]. Ministry of Health and Family Welfare has framed guidelines for clinical management of COVID-19 [40].

Table 1 Indian Council of Medical Research—Department of Health Research: strategy for COVID-19 testing in India (Version 4, dated 09/04/2020)

1. All symptomatic individuals who have undertaken international travel in the last 14 days
 2. All symptomatic contacts of laboratory-confirmed cases
 3. All symptomatic health care workers
 4. All patients with Severe Acute Respiratory Illness (fever AND cough and/or shortness of breath)
 5. Asymptomatic direct and high-risk contacts of a confirmed case should be tested once between day 5 and day 14 of coming in his/her contact
- In hotspots/cluster (as per MoHFW) and in large migration gatherings/evacuees centres**
6. All symptomatic ILI (fever, cough, sore throat, runny nose)
 1. Within 7 days of illness—rRT-PCR
 2. After 7 days of illness—antibody test (if negative, confirmed by rRT-PCR)

Safety Measures for Doctors and Health Care Workers

Globally at least 22,000 health care workers have been infected at the time of this report, with Italy reporting the highest percentage (20%) [41]. 26 orthopaedic surgeons from 8 hospitals were identified in a recent survey of orthopaedic surgeons with COVID-19 in Wuhan [8]. 79.2% got the exposure in the general ward whereas 20.8% got it in public places in hospital, 12.5% in operation theatre, 4.2% in intensive care units and 4.2% in the outpatient clinic. Transmission from these doctors to others took place in 25% of cases and was most commonly to family members (20.8%) followed by colleagues (4.2%), patients (4.2%) and friends (4.2%) This stresses the importance of the immediate implementation of Infection Prevention and Control measures.

Factors found to have a protective effect against COVID-19 in the survey of infected orthopaedic surgeons in Wuhan included participation in real-time training on preventive measures and wearing respirators or masks all the time. Risk factors included not wearing an N95 respirator and severe fatigue [8].

SARS-CoV-2 transmits very rapidly and easily (has 10–20 times higher affinity than SARS) especially since human beings have no immunity to the new disease [9]. Neither a vaccine has been developed as yet nor pharmacological prophylaxis established as of date (though Ministry of Health and Family Welfare, Govt of India guidelines recommend Hydroxychloroquine for Health Care Workers) [42]. Hence social distancing (ideally 2 m but at least 1 m), engineering as well as administrative controls for prevention and the implementation of Infection Prevention and Control Measures like personal protective equipment (PPE), hand hygiene (washing with soap and water for 20 s or using an alcohol based sanitizer), avoiding touching face, mouth or eyes as well as other universal flu precautions and waste management materials assumes great importance as does real-time training on preventive measures.

The Protective equipment consists of garments placed to protect the health care workers or any other persons from getting infected through the risk of contact and droplet transmission during their daily work. These usually consist of standard precautions: face protection, goggles and mask or faceshield, gloves, gown or coverall, head cover and rubber boots. Health care workers need to be trained for their use, especially with regard to the precautions to be taken during donning and doffing [43].

There are WHO and various national guidelines which provide PPE guidance in the health care context [43, 44]. There are minor variations to reflect pandemic evolution

and the changing level of risk of health care exposure. Hence it is recommended to use National guidelines which also may get updated from time to time. The Indian National guidelines are illustrated in Supplemental information [43].

Limited reuse has been recommended; this has been widely practiced as an option for conserving respirators during previous respiratory pathogen outbreaks and pandemics. CDC guidelines also recommend practices allowing extended use and/or limited reuse of N95 respirators, when acceptable [45]. However, the right balance needs to be achieved since reuse/extended use carries the risk of contact transmission by touching respirator surfaces.

Temporal separation of hospital staff through constitution of teams and suitable rosters allowing segregation of health care workers is also recommended to reduce the chances of cross infection [46].

A protocol should be in place regarding the needful to be done in case of inadvertent exposure of any health care worker to COVID-19 patient. The protocol should include quarantining of those exposed and sanitising the area.

Negative mental health effects amongst physicians are quite common during the pandemic [47]. They get caught between the call of their duty to care for their patients on the one hand and concerns about the risk of infection and transmitting it to their family and friends on the other. They are not only overloaded with work, they also need to make very difficult and emotionally draining triage decisions. Moreover there is the pain of patients and colleagues succumbing to the disease. As per a study published in the JAMA, 70% of front line health care workers in Hubei suffered from severe stress, whereas 50% had depressive orders, 44% anxiety and 34% insomnia [48]. Hence it is important for them to use helpful coping strategies such as ensuring sufficient rest during work or between shifts. Eating sufficient and healthy food, engaging in physical activity, staying in contact with family and friends and using strategies that have worked for them in the past to manage times of stress are essential.

Thus adequate protection of doctors and health care workers and ensuring their physical as well as mental health assumes prime importance. An editorial in the Lancet appropriately mentions, “health-care workers, unlike ventilators or wards, cannot be urgently manufactured or run at 100% occupancy for long periods. It is vital that governments see workers not simply as pawns to be deployed, but as human individuals” [*The Lancet. Editorial, 2020, P 922*] [41].

Management of Orthopaedic Disease During Pandemics

See Table 2.

Table 2 Do's and Don'ts during pandemic for orthopaedic surgeons*Do's*

1. Consider each case admitted in hospitals in and around containment zones as COVID-19 positive
2. Screening should be done for all patients visiting the hospital
3. Consent should have information that COVID-19 could be transmitted from any of the other admitted patients who may be asymptomatic or in incubation period of the disease
4. Follow religiously infection prevention and control measures
5. Outpatient visits should be reduced. Telemedicine consultations should be encouraged
6. Conservative treatment should be the first line of treatment except for those with red flag signs
7. Structured communication should regularly be organised between all stakeholders for pre-surgical planning and operation theatre transfer
8. Surgical management should be planned as per risk stratification strategy
9. OT environment, anaesthesia and surgical plan should be modified to minimize the spread of infection
10. The surgical team should consist of experienced surgeons and not trainees
11. Look for the opportunity within the adversity

Don'ts

1. Do not neglect precautions for personal protection
2. Do not see any patients who has not been screened at the hospital
3. Do not mix non-COVID with COVID suspected cases
4. Do not mix the isolation areas for COVID-suspected and COVID
5. Do not be over enthusiastic in advocating surgical management
6. Do not bypass the workflow of the OR for COVID positive cases
7. Do not waste time. Utilise it for consolidating your practise and giving due consideration to education and research

Management Principles [50–53]

Principles of management of patients during pandemic could have some differences during and outside the lockdown period.

- The aim of an Orthopaedic surgeon is to provide optimal treatment to patients with orthopaedic problems. During the pandemic, in addition, the orthopaedic surgeon has to endeavour to ensure the protection of the patient, himself/herself, other health care workers and other patients. Optimal use of health care resources becomes vital during the pandemic.
- All patients/visitor staff visiting the hospital should be screened for fever and any suggestive symptoms.
- COVID-19 patients have to be treated separately.
- Conservative treatment should be the first line of treatment except for traumatic cases and those with red flags. Temporary pain-alleviating measures like intra-articular corticosteroids or nerve blocks should be considered.
- During the lockdown, all elective procedures are withheld. After the period of lockdown some balance may need to be achieved between trying to prevent spread of COVID-19 and provision of continuity of patient care. Surgeries that can be performed with daycare admission could be allowed.
- The suggested risk stratification for surgery during the pandemic is as under [49]:
 - o Elective surgery: Chronic problems where surgery can be delayed without significant difference in eventual outcome or harm to the patient.
 - o Urgent, somewhat elective surgery: As the virus becomes more prevalent, surgeries for injuries such as ACL, meniscal injuries, rotator cuff tears, biceps injuries, intraarticular displaced radial fractures should be still performed, possibly in an outpatient/day care setting to minimize utilization of resources.
 - o Urgent only: As resources assume paramount importance and virus becomes more prevalent, only injuries in which immediate surgical intervention would prevent significant impairment of function such as fracture dislocations, pilon fractures, cauda equina syndrome etc. should be considered.
 - o Emergency only: In this situation, the hospital and ICU would be having critical shortage of resources and only life or limb threatening injuries should be taken to surgery. The goal should be to minimize the need for ventilator support e.g. using spinal anaesthesia for surgery, even if it is outside the usual standard of care.
- All attempts should be made to reduce hospital revisits. Telemedicine is useful not only in this regard but also for first consultation.
- Other than social distancing amongst the doctors and health care workers, temporal separation is also required to reduce spread of infection.

Screening and Triage [54–57]

To prevent or reduce the chance of nosocomial cross infections screening of all patients and visitors coming to the hospital, whether the outpatient or emergency, assumes special

importance and involves taking a brief history pertaining to risk factors and checking temperature with a thermal scanner (WHO recommends cut off value of 37.3 °C). Patients should be encouraged to visit the hospital only after a prior appointment (except for emergencies) through telephone/online. This can be used as an opportunity to collect information pertaining to recent travel history, contact with infected case, residence in a hotspot or COVID-19 cluster area and clinical symptoms like fever, dry cough and fatigue. Visitors of patients should not be allowed inside the hospital during the period of lockdown. All visitors should be made to register as it would be important for contact tracing if necessary.

Patients with fever or those suspected on screening should be referred to flu desk/other designated area for further evaluation. Only those with normal screening results should be allowed to visit the outpatient department or emergency.

Orthopedic Outpatient and Emergency

During the COVID-19 pandemic, only more critical and serious patients like those with trauma, tumor, infections and post-operative complications are likely to visit outpatients or emergency [57]. However as the restrictions get relaxed after the lockdown, there is likely to be a sudden increase in the number of patients visiting outpatient clinics. It may be prudent that the norms of social distancing are followed. The number of appointments scheduled have to be also planned accordingly.

Only those with normal screening should be provided consultation in the regular orthopaedic outpatient department or emergency. At some facilities, complete blood count and CT chest are recommended for all patients. Patients with fever or travel/contact history and severe orthopaedic disease should be seen in the isolation room with protection for doctors as for confirmed COVID-19 cases. If evaluation suggests the possibility of COVID-19 disease, appropriate diagnostic testing and self-quarantine is advised. If COVID-19 is confirmed, the patient should be referred to a dedicated facility [58].

The British Orthopaedic Association (BOA) has emphasized the management of outpatient events by non-surgical methods and to minimize the number of outpatient visits.

The guidelines also specify the usage of removable casts and splints to minimize routine follow ups and has discouraged the use of repeated radiographs for fracture union [50].

Orthopaedic Inpatient Facility for COVID-19 Negative, COVID-19 Suspect and Confirmed Cases

In India, a facility can manage COVID-19 positive cases only after approval from concerned authorities. In fact the government has identified COVID-19 hospitals which are

designated for management of COVID-19 positive patients only [59]. In addition, Indian Railways is converting 5000 train coaches across the country to serve as quarantine/isolation facilities for 80,000 beds for COVID-19. Conversion of 3250 coaches had already been completed as of 8th April 2020 [60]. However, any institution would have COVID-19 suspect cases for which prevention precautions need to be taken as for COVID-19 positive cases till such time they are proved to be negative. As per the recent government guidelines all patients being admitted to a health care facility in and around containment zones should undergo diagnostic testing for COVID-19 [58].

The facility for COVID-19 cases should be either a dedicated building or block separate from the rest of the hospital. Isolation areas like wards or rooms need to be different for suspected and confirmed cases and under no circumstances should be mixed. There should be separate entry and exit for patients and staff. Ventilation should be good, and if possible, there should be negative pressure. Donning and doffing area for staff should be next to the patient care area preferably with a shower area. There should be dedicated facilities for screening, testing etc. [59].

Proper infection protection and control measures are very important while managing COVID-19 patients. Interdepartmental referrals pose a potential risk of disease transmission.

Separate yellow, red/black bags in foot operating dustbins should be kept at each floor and outside the facility to ensure safe biomedical waste management as per standard guidelines. Health care workers collecting the possible infectious material such as food items, PPE kits, etc. from yellow bags should also wear PPE and follow the infection prevention and control measures. A designated place has to be earmarked outside the building for collection of yellow and black bags and the waste should be collected at least twice daily by biomedical waste management vehicle or as per any other locally established practice [61].

Special Considerations for Anaesthesia

In patients infected with COVID-19, the risk of respiratory failure requiring intensive care support is significant and anaesthesia teams must be prepared for the care of such patients [62]. Positive pressure airflow environment of the operation theatre can create a risk of viral spread and hospitals should consult with biomedical engineers and operating rooms converted to negative pressure environment with 10–12 airflow changes per hour [62]. Wherever possible, regional anaesthesia should be used. The Royal College of Surgeons has suggested that in emergency conditions due to increasing prevalence of COVID-19 disease, the need for ventilator support for surgeries should be minimized, e.g. using spinal anaesthesia for surgery, even if it is outside the usual standard of care [63]. High risk aerosol generating

procedures such as intubation, should not be performed in a positive pressure environment. Use of intravenous anaesthesia would be preferred to using inhalational anaesthesia since these patients are not likely to be extubated early [62].

Factors such as high viral shedding due to severe illness, aerosol-generating procedures such as intubation and improper use of PPE can cause health care worker transmission [62]. Intubation must be performed by the most skilled person using a rapid sequence intubation technique [62]. All necessary equipment for intubation should be made available before attempt and the recurrent traffic of people bringing equipment should be reduced. The number of personnel in the operation theatre at the time of intubation should be reduced to essential team members only [62]. The circuits used during anesthesia and the soda lime canister should be changed after each procedure to avoid possible contamination.

Special Consideration for Orthopaedic Surgeries

Structured communication should regularly be organized between all stakeholders for presurgical planning and operation theatre transfer. All patients requiring surgery during the pandemic in and around containment zones should preferably get an rRT-PCR test done in addition to the routine pre-anesthetic check-up [64]. Some physicians prefer to get a routine CT chest done in addition [65]. Others also prefer to get a SARS-CoV-2 nucleic acid test and CT repeated 3 days after surgery [66]. Those who test negative for COVID-19 in pre-anesthetic check-up undergo the surgery in a routine manner. However, the importance of prevention precautions cannot be undermined.

A separate operation Room (OR), if possible a satellite unit, should be exclusively dedicated for surgeries of COVID-19 positive cases. It is assumed that the entire OR will be contaminated and prevention precautions taken accordingly. If possible, there should be separate access. There should be prominent signages depicting it as a COVID-19 OR. An exit room leading to an outside corridor could be used as an exit room for surgical staff.

Normally positive pressure environment is maintained in OR. However, in order to reduce dissemination, the OR for COVID-19 cases should have a negative pressure environment [62]. If this is not possible, the positive pressure could be turned off and if possible, a portable HEPA filtration system with high frequency of air changes could be used. The use of hoods in positive pressure systems are to be discouraged. If used as a visor, the fan should be disconnected.

The COVID-19 OR complex could be divided into five zones; entry dressing room where the basic PPE is donned, anteroom for disinfection and surgical dressing, COVID-19 OR, exit room where PPE is removed and exit dressing room where the staff shower (Fig. 1). Each of the zones should

have appropriate material to wear and waste baskets to discard used garments. In the entry dressing room the surgical staff should don gloves, the basic PPE disposable scrub suit, surgical boots, waterproof boot or shoe covers, waterproof apron and a N-95 respirator. In the ante room a lead garment is worn if required, followed by a second layer of sterile protective garments as well as a surgical cap with mask and shield (or face shield). Appropriate surgical hand scrubbing could be done with donned gloves. The disposable sterile surgical gown followed by the second pair of gloves is now donned. OR technicians helping in positioning and traction etc. should don PPE, but it need not be sterile.

Access to COVID-19 OR should be restricted, and only the minimum number required should be in the OR. During the surgery, staff should leave the OR only under exceptional circumstances [62].

In the OR certain precautions need to be taken during surgery. Where possible the scope of surgery should be reduced in order to shorten the surgical time [67]. Minimally invasive procedures should be used where possible. Prone position reduces the chance of transmission by droplets [67]. Electrocautery, power drills, screws and reamers are aerosol generators and can increase the risk of transmission [67]. Suction devices could be used during surgery to remove smoke and aerosols. Chances of body fluid spillage should be minimized by gentle handling [67].

After the procedure, the surgeons should first remove the second pair of gloves as well as the gown and disinfect the first pair of gloves with an alcohol solution. The surgical mask with shield and cap could then be removed. Before leaving the OR the first pair of gloves should be removed and the hands disinfected with an alcohol solution. The OR staff should remove the PPE in the exit room before moving to the exit dressing room for a shower. There is a high chance of disease transmission during donning and especially doffing, and hence special precautions should be taken, including using a Buddy system for facilitation [68].

Decontamination and Disinfection

The OR should have only minimal equipments, which reduces the laborious task of disinfection. Disposable equipments are preferred and whenever possible, the OR devices such as monitors, fluoroscopy devices, ultrasound machines and ventilators, etc. need to be wrapped with plastic sheets. It is also necessary to disinfect all the medical devices and surfaces of operating tables, footstools and microscopes with quaternary ammonium chloride wipes. The entire OR is then cleaned with sodium hypochlorite and treated with ultraviolet-C irradiation. The turnaround time has to be increased to ensure proper disinfection. The importance of waste management according to the biohazard principles needs strict attention and preferably supervised. The infection control

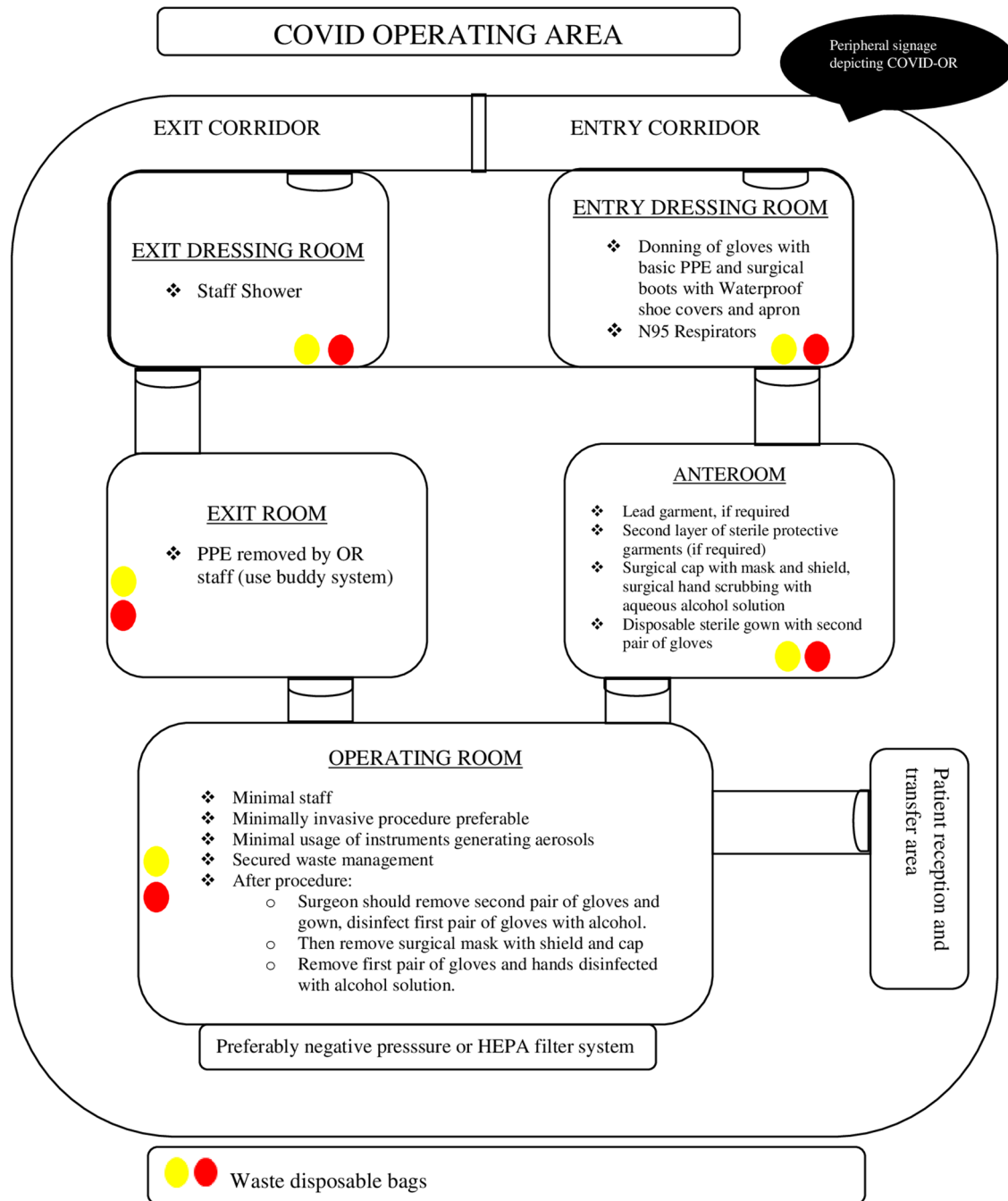


Fig. 1 A line diagram detailing the ideal operation theatre set up during COVID pandemic

department of any hospital needs to ensure that each health care worker from scrub nurse to sanitary workers are trained well to use PPE competently with emphasis on proper doffing techniques to prevent self-contamination.

The above written practices should be taken care of at each level of care while handling these patients, at the OR, ICU, post-operative recovery rooms, during nursing, rehabilitation and shifting them.

Special Considerations in Rehabilitation [70–72]

Rehabilitation is an important component of the management of orthopaedic diseases. Since therapists have to work in close contact with patients, screening for COVID-19 assumes special importance before therapy sessions are initiated. Special precautions should be taken during cardio-respiratory rehabilitation of patients with neurological deficits.

Cardio-pulmonary rehabilitation plays a prominent role in the management of COVID-19 cases and the same would hold true for orthopaedic patients who are COVID-19 positive.

During the pandemic, all patients, family members and caregivers are stressed and hence psychosocial rehabilitation has a very important role, especially in the case of COVID-19 positive patients.

Special Considerations for Spinal Injury Patients

Spinal cord injury (SCI) individuals are at a higher risk for respiratory-related viral infections such as influenza. Also, studies show that chronic SCI attenuates virus-specific humoral and cellular immunity during the establishment of primary response and impairs the development of memory CD8⁺ T cells [72].

SCI individuals are also prone to fever (range – 22.5 to 71.7%; mean 50.6%) due to other causes, which may be confused with a viral infection. SCI individuals are also prone to complications such as pressure ulcers, urinary tract infections, etc. which are avenues for bacteria and viruses to enter the body [73, 74].

Implications on Length of Hospital Stay

Where possible, the length of the hospital stay should be kept as short as possible for all patients. However, this holds special relevance during the pandemic. Hence as elective surgeries resume after the lockdown, daycare surgeries would probably be given preference.

In COVID-19 positive patients with orthopaedic emergencies, the length of stay is likely to be longer than that for normal patients [75].

Optimisation of Resources

Since revenue generation is being affected substantially, there is a need for cost control and optimization of resources. There should be a regular appraisal of available resources and resource allocation as well as patient prioritization should be agreed upon accordingly.

The ramping up of the “Make in India” initiative by the Indian Government in a big way should help in the much needed availability of PPEs, sanitizers, ventilators and other equipment at an affordable price and reduced dependence on imports [76].

Financial Implications of COVID-19 Pandemic

Inefficient financial decisions, avoidable losses, and unnecessary anxiety are endemic during crisis situations like this COVID-19 pandemic. This may be the right time to think in

terms of diversification and investing in a parallel source of income. While to most this would mean the stocks, the real estate and gold, one must remember that the best investment one can make is in one self. It may be right time to invest in oneself and one’s own practice. This may mean, acquiring a new skill set (could be professional or even personal like a language), upgrading technology at one’s facility (think electronic medical records, telemedicine, insurance desk) or planning logistics to launch an outreach activity to improve patient flow.

One should revisit the financial planning during COVID-19 with the key pointers of budgeting for success, prioritizing long-term goals, building an emergency fund and tracking long-term goals.

Special Considerations for Emerging Countries

The adverse impacts of COVID-19 on health and welfare are likely to be considerable in low-income or middle-income countries (LMICs), especially in rural areas where medical infrastructure is not developed [77]. The capacity of weak health-care systems to manage a surge of severe pneumonia is limited, as is the low availability of appropriate personal protective equipment (PPE) for front-line health-care staff [78]. Disruption or complete breakdown of those health-care systems would result in high direct and indirect mortality since care of all illness would be affected [78].

Despite international efforts, there remain substantial organizational and bureaucratic obstacles. Strong political support, effective collaboration, adequate expertise and resources, and informed guidance will be needed to overcome these barriers.

Role of Telemedicine

With time, telemedicine-assisted orthopaedic practice has become a mainstream component in routine orthopaedic parlance. Several secure and encrypted applications have been developed and studied, such as MyDoc at the National University Hospital in Singapore [79].

A 2018 article by the Journal of the American Association of Paediatrics proved an excellent agreement between physical examination and video-assisted consultation for adolescent patients having undergone knee arthroscopy [80]. Virtual fracture clinics are well established and accepted in the United Kingdom and are well-encouraged by the Royal College of Surgeons (RCS) Clinical Practice Guidelines, for a follow-up perspective [63, 81]. Patient outcomes, such as knee range of movements after arthroplasties, can be monitored remotely without the need for hospital visits using technologies such as wearable sensors and videoconferencing tools [82]. Technology assisted rehabilitation like online educational platforms or game-based therapy help improve

patient outcomes. However, the value of telemedicine has always remained second to in-person history taking, clinical examination, and clinical decision making.

However, with the SARS-CoV2 outbreak, there has been a paradigm shift in this line of thought. With most nations being pushed to the brink of community transmission and medical professionals on the front line, this situation has forced a re-look at the implications of telemedicine in the day-to-day life of an orthopaedic surgeon. The British Orthopaedic Association has, as per their BOAST guidelines, recommended the change-over of most if not all “non-essential” clinic visits to a virtual out patient fracture clinic set-up [50].

On the 25th of March 2020 the Medical Council of India in partnership with NITI Aayog published the TELEMEDICINE Guidelines, which constitutes Appendix 5 of the Indian Medical Council (Professional Conduct, Etiquette, and Ethics Regulation, 2002) [83]. The guidelines give details of maintaining a digital trail/documentation of the consultation, fee for Telemedicine consultation (which could be the same as in-person consultation) and guidelines for platforms rendering Telemedicine consultations [83].

Promoting the use of Telemedicine considering its advantages should be balanced against the unavailability of reliable internet and technological support in many regions of India and other emerging countries.

Orthopaedic Education and Training [84]

Orthopaedic training has definitely been affected during the ongoing pandemic due to suspension of in-person teaching programs and cancellation of elective surgical procedures.

The pandemic of COVID-19 has certainly altered the Dynamics of the World in more ways than one. The paradigm of communication and the definition of education has been amended. The didactic teaching modules and the convention of congregations are in the phase of being remoulded if not getting obsolete.

The path that this has taken and the trajectory in which it is being directed seems to be analogous with the Phases of Bone Modelling. Phase 1 representing the past could be considered to be analogous to Quiescence and Apoptosis. It was a phase of consolidation in which confusion abounded the world of medical teaching and training. Legislative uncertainties attempts to quantify restrictions, and consolidating available resources were the defining features of this phase. Certain pre-existing platforms native to the country were the few official, non-commercial web portals for teaching and training of postgraduates and orthopaedic surgeons.

Phase 2 is analogous to the recruitment phase of bone remodeling and represents the present with an explosion of Online Education. Many reputed national associations and their members have taken a lead in the process. On the flip side, many online Web Portals seem to be guarding the

commercial interests of their stake holders. There are very strong undercurrents of personal data being collected and circulated. There are, however, certain National and International Portals which are serving unfiltered and unbiased online Education which is peer recognized.

Phase 3, analogous to resorption, differentiation, and consolidation of bone remodelling, represents the future scenario where education is likely to be based on E learning. Associations, Societies and the Industry are likely to form formidable partnerships with investments towards integrated platforms. Solicited and non-peer reviewed portals are likely to come under the scanner of legislation purely because of the bias towards monetary gains. Online courses, Structured short-term training programs, Online clinical skills workshops based on simulation, Integrated artificial intelligence platforms and E learning remote classrooms are most likely to become the norm. Augmented reality and training on surgical simulators, rather than patients is likely to become the norm. Wearable technology, smart phones and other hand-held devices are likely to evolve into hardware and software portals for residency programs across the world. The real challenge lies with the patient confidentiality laws of the country that are not very stringent at the moment but are likely to be amended soon.

The unexpected circumstances also require doctors to work beyond their practiced competencies. Surgeons should receive appropriate training, support and mentoring in their extended scope of practice [63]. WHO Health emergencies program has developed an online course on how to detect, prevent, respond to and control the COVID-19 infection [85].

Research and Innovation

Extraordinary times require extraordinary measures. It is time that world opens itself to Research, Development, and Innovation. COVID-19 is primarily a medical condition, and yet we as orthopaedic surgeons can respond to crisis with our in-built ingenuity that we have acquired in operating rooms over years. Our relationship with the medical device industry can act as a catalyst. Some of the areas in which the orthopaedic surgeons have familiarity and can deploy their knowledge and skills to be a part of the solution include 3D printing parts and designing of ventilators, isolation tents and negative pressure room concept, AI and big data for analytics, regenerative medicines, Robotic un-manned devices for sanitization and PPE improvisation as well as mass productions [86, 87] (Fig. 2).

Prospective orthopaedic research may not be possible but academic writing and retrospective orthopaedic related research that may have been pending secondary to paucity of time could be pursued. The technology is an ideal ground enabling us to divide and conquer. There may



Fig. 2 Image showing a 3D printed ventilator splitter designed by an orthopedic surgeon with his 3D printing team

be several orthopaedic residents and fellows who would find themselves with spare time at hand to contribute to research papers, academic books and book chapters. Many university courses and online resources are now freely available, and it is the right time to collaborate, innovate and excel. Most areas of academic contributions are well known to those in academic background, but these times also offer an opportunity to contribute to the point of view and letters to editor that are rapidly reviewed and their publications fast-tracked.

Medicolegal Aspects

Though elective procedures and outpatient visits have been suspended, emergency services should continue, though with due precautions.

On 11th March 2020 the Central government decided that all states should be advised to invoke the necessary provisions of the Epidemic Disease Act, 1897 and enforce all advisories. The government can co-opt private hospitals and the services of private doctors as well as health care workers, as required in public interest. The government can take over hospitals or even temporarily nationalize healthcare in the country. It can withhold or reduce salaries or curtail employment, if it deems necessary.

All doctors, including Orthopedic surgeons are duty bound to obey the government's instructions, communicated directly or through the media or through the District Administration.

Since healthcare workers are vulnerable to get infected during their duties, under the Financial package of 26th March 2020 the government has announced a special health Insurance of Rs 50 lakhs per person which would be applicable to doctors from private sector also.

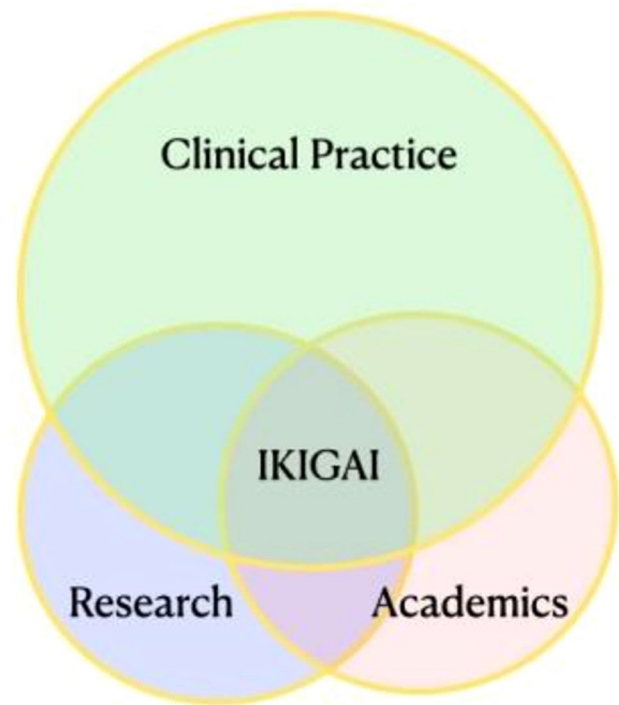


Fig. 3 'Ikigai' means a reason for being. Orthopaedic Ikigai could be achieved by a combination of clinical practice, academics and research

For staff dealing with COVID-19 positive cases, adequate quarantine after duty hours, including isolation from family members, should be ensured.

The Road Ahead

The pandemic offers significant lessons in courage, team work, banding as well as bonding, compassion, leadership traits, rational management of limited resources, versatility, adaptability to an everchanging fluid situation and the value of systems in practice and organization. It is also likely to uncover a tale of empathy, apathy, fragility, and antipathy in human civilization. However, most importantly, it will force us to introspect and dig deeper on what really matters. Every adversity brings with it an opportunity and as orthopaedic community we must use this time wisely to achieve our Ikigai (Fig. 3). For most us it will be a combination of our clinical practice, academics and research apart from our personal and philanthropic pursuits. A small step in the right direction is often what is needed to embark on a full filling journey. The *time is now* because, like everything in the world, this too shall pass...

"Sometimes, the greatest storms bring out the greatest beauty...Life can be a storm, but your hope is a rainbow and your friends and family are the gold." *Steve Maraboli*.

Conclusions

These are difficult times due to the COVID-19 pandemic which has had an enormous impact globally on health, survival as well as economy. As responsible orthopaedic surgeons, it is our moral responsibility to try to dampen the impact of the pandemic in which ever manner possible. We should be vigilant, observe infection prevention and control measures and try to come out with innovative strategies to overcome the challenges posed by the pandemic.

In these trying times we need to stay in closer touch and brainstorm not only on how we can contribute to the resolution of the crisis but also use it as an opportunity to learn from it and build a more positive and inclusive future. Let us rise up to the challenge posed by COVID-19 pandemic.

Funding None.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no competing interest.

Ethical standard statement This article does not contain any studies with human or animal subjects performed by the any of the authors.

Informed consent For this type of study informed consent is not required.

References

- Wang, C., Horby, P. W., Hayden, F. G., & Gao, G. F. (2020). A novel coronavirus outbreak of global health concern. *Lancet*, *395*(10223), 470–473.
- Huang, C., Wang, Y., Li, X., Ren, L., Zhao, J., Hu, Y., et al. (2020). Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet*, *395*, 497–506.
- Zhu, N., Zhang, D., Wang, W., Li, X., Yang, B., Song, J., et al. (2020). A novel coronavirus from patients with pneumonia in China, 2019. *New England Journal of Medicine*, *382*, 727–733.
- WHO. Naming the coronavirus disease (COVID-19) and the virus that causes it. [https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/naming-the-coronavirus-disease-\(covid-2019\)-and-the-virus-that-causes-it](https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/naming-the-coronavirus-disease-(covid-2019)-and-the-virus-that-causes-it).
- World Health Organization. WHO Director-General's opening remarks at the media briefing on COVID-19. 2020. <https://www.who.int/dg/speeches/detail/whodirector-general-s-opening-remarks-at-the-media-briefing-oncovid-19-11-march-2020>. Accessed 12 Mar 2020.
- WHO. Coronavirus disease (COVID-19) Pandemic. <https://www.who.int/emergencies/diseases/novel-coronavirus-2019>.
- Udwadia, Z. F., & Raju, R. S. (2020). How to protect the protectors: 10 lessons to learn for doctors fighting the COVID-19 Coronavirus. *Medical Journal Armed Forces India*, *20*, 20.
- Guo, X., Wang, J., Hu, D., Wu, L., Gu, L., Wang, Y., et al. (2020). Survey of COVID-19 disease among orthopaedic surgeons in Wuhan, People's Republic of China. *Journal of Bone and Joint Surgery*, *20*, 8.
- Zhang, H., Penninger, J. M., Li, Y., et al. (2020). Angiotensin-converting enzyme 2 (ACE2) as a SARS-CoV-2 receptor: Molecular mechanisms and potential therapeutic target. *Intensive Care Medicine*, *46*, 586–590. <https://doi.org/10.1007/s00134-020-05985-9>.
- Wrapp, D., Wang, N., Corbett, K. S., Goldsmith, J. A., Hsieh, C. L., Abiona, O., et al. (2020). Cryo-EM structure of the 2019-nCoV spike in the prefusion conformation. *Science*, *367*, 1260–1263.
- Lu, R., Zhao, X., Li, J., Niu, P., Yang, B., Wu, H., et al. (2020). Genomic characterisation and epidemiology of 2019 novel coronavirus: Implications for virus origins and receptor binding. *Lancet*, *395*(10224), 565–574.
- Wang, W., He, J., Lie, P., Huang, L., Wu, S., Lin, Y., et al. (2020). The definition and risks of cytokine release syndrome-like in 11 COVID-19-infected pneumonia critically ill patients: Disease characteristics and retrospective analysis. *medRxiv*, *20*, 20.
- Nazinitsky, A., & Rosenthal, K. S. (2010). Cytokine storms: Systemic disasters of infectious diseases. *Infectious Diseases in Clinical Practice*, *18*(3), 188–192.
- Guan, W. J., Ni, Z. Y., & Hu, Y. (2020). Clinical characteristics of coronavirus disease 2019 in China. *The New England Journal of Medicine*, *20*, 28.
- Kasibhatla, S. M., Kinikar, M., Limaye, S., Kale, M. M., & Kulkarni-Kale, U. (2020). Understanding evolution of SARS-CoV-2: A perspective from analysis of genetic diversity of RdRp gene. *Journal of Medical Virology*. <https://doi.org/10.1002/jmv.25909>.
- Li, R., Pei, S., Chen, B., Song, Y., Zhang, T., Yang, W., et al. (2020). Substantial undocumented infection facilitates the rapid dissemination of novel coronavirus (SARS-CoV2). *Science*, *20*, 16.
- Ng, K., Poon, B. H., Kiat Puar, T. H., Shan Quah, J. L., Loh, W. J., Wong, Y. J., et al. (2020). COVID-19 and the Risk to Health Care Workers: A Case report. *Annals of Internal Medicine*, *20*, 20.
- Santarpia, J. L., Rivera, D. N., Herrera, V., Morwitzer, M. J., Creager, H., Santarpia, G. W., et al. (2020). Transmission potential of SARS-CoV-2 in viral shedding observed at the University of Nebraska Medical Center. *medRxiv*, *1*, 20.
- Van Doremalen, N., Bushmaker, T., Morris, D. H., Holbrook, M. G., Gamble, A., Williamson, B. N., et al. (2020). Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. *New England Journal of Medicine*, *20*, 17.
- WHO Infection Prevention and Control Guidance for COVID-19. <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/infection-prevention-and-control>. Scientific brief 29 Mar 2020.
- Hindson, J. (2020). COVID-19: Faecal–oral transmission? *Nature Reviews Gastroenterology & Hepatology*. <https://doi.org/10.1038/s41575-020-0295-7>.
- Game, F. L., Hinchliffe, R. J., Apelqvist, J., et al. (2012). Specific guidelines on wound and wound-bed management 2011. *Diabetes Metabolism Research and Reviews*, *28*(Suppl 1), 232. <https://www.mohfw.gov.in>. Updates on COVID-19. Accessed 04 Apr 2020.
- COVID-19 Surveillance Group. Characteristics of COVID-19 patients dying in Italy Report based on available data on March 20th, 2020. https://www.epicentro.iss.it/coronavirus/bollettino/Report-COVID-2019_20_marzo_eng.pdf.
- Clinical management of severe acute respiratory infection (SARI) when COVID-19 disease is suspected: Interim guidance 13th March 2020. <https://www.who.int/emergencies/diseases/novel-coronavirus-2019>.
- Team NCPERE. (2020). Vital surveillances: The epidemiological characteristics of an outbreak of 2019 novel coronavirus diseases (COVID-19)—China. *China CDC Weekly*, *2*(8), 113–122.

27. Li, H., Liu, Z., & Ge, J. (2020). Scientific research progress of COVID-19/SARS-CoV-2 in the first five months. *Journal of Cellular and Molecular Medicine*, 2, 22.
28. Richardson, S., Hirsch, J. S., Narasimhan, M., Crawford, J. M., McGinn, T., & Davidson, K. W. (2020). Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York City area. *JAMA*, 20, 22.
29. WHO. WHO Director-General's opening remarks at the media briefing on COVID-19-3 March 2020. <https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---3-march-2020>.
30. Singhal, T. (2020). A review of coronavirus disease-2019 (COVID-19). *Indian Journal of Pediatrics*, 87(4), 281–286.
31. Shuchang, Z., Yujin, W., Tingting, Z., & Liming, X. C. T. (2020). Features of Coronavirus Disease 2019 (COVID-19) (COVID-19) pneumonia in 62 Patients in Wuhan, China. *American Journal of Roentgenology*, 20, 1–8.
32. Emery, S. L., Erdman, D. D., & Bowen, M. D. (2004). Real-time reverse transcription-polymerase chain reaction assay for SARS-associated coronavirus. *Emerging Infectious Diseases*, 10(2), 311–316.
33. U.S Food and Drug administration. Important Information on the use of serological(antibody) tests for COVID-19-letter to health care providers. <https://www.fda.gov/medical-devices/letters-health-care-providers/important-information-use-serological-antibody-tests-covid-19-letter-health-care-providers>.
34. The Wall Street Journal. How South Korea Put into place the world's most aggressive coronavirus test program. 2020. <https://www.wsj.com/articles/how-south-korea-put-into-place-the-worlds-most-aggressive-coronavirus-testing-11584377217>
35. Indian Council Of Medical Research, Department Of Health Research. Strategy for COVID19 testing in India (Version 4, dated 09/04/2020). https://icmr.nic.in/sites/default/files/uploads_documents/Strategy_for_COVID19_Test_v4_09042020.pdf.
36. <https://www.investindia.gov.in/team-india-blogs/government-approved-testing-centers-covid-19-india>. Updated 2 Apr 2020.
37. Cao, B., Wang, Y., Wen, D., Liu, W., Wang, J., Fan, G., et al. (2020). A trial of Lopinavir–ritonavir in adults hospitalized with severe Covid-19. *The New England Journal of Medicine*, 20, 20.
38. Wang, M., Cao, R., Zhang, L., Yang, X., Liu, J., Xu, M., et al. (2020). Remdesivir and chloroquine effectively inhibit the recently emerged novel coronavirus (2019-nCoV) in vitro. *Cell Research*, 30, 269–271.
39. Keith, P., Day, M., Perkins, L., Moyer, L., Hewitt, K., & Wells, A. (2020). A novel treatment approach to the novel coronavirus: An argument for the use of therapeutic plasma exchange for fulminant COVID-19. *Critical Care*, 24, 128.
40. Government of India Ministry of Health and Family Welfare Directorate General of Health Services (EMR Division). Revised Guidelines on Clinical Management of COVID-19. 2020. <https://www.mohfw.gov.in/pdf/RevisedNationalClinicalManagementGuidelineforCOVID1931032020.pdf>.
41. (2020) COVID-19: Protecting health care workers. *The Lancet*. 395, 10228, 922.
42. Center for Disease Control and Prevention. (2020). Corona virus disease 2019 (COVID-19). How to protect yourself and others. (<https://www.cdc.gov/coronavirus/2019-ncov/about/prevention-treatment.html>).
43. Ministry of Health and Family Welfare. (2020). Revised guidelines on clinical management of COVID-19. <https://www.mohfw.gov.in/pdf/GuidelinesonrationaluseofPersonalProtectiveEquipment.pdf>.
44. World Health Organization (WHO). (2020). *Rational use of personal protective equipment for corona virus disease. Interim Guidance*. Geneva: WHO.
45. The Centers for Disease Control and Prevention (CDC). (2019). Recommended guidance for extended use and limited reuse of N95 filtering facepiece respirators in healthcare settings. <https://www.cdc.gov/niosh/topics/hcwcontrols/recommendedguidanceextendeduse.html>.
46. Hoe Gan, W., Wah Lim, J., & Koh, D. (2020). Preventing intra-hospital infection and transmission of COVID-19 in health-care workers. *Saf Health Work*. <https://doi.org/10.1016/j.shaw.2020.03.001>.
47. Silva, A. G., Miranda, D. M., Diaz, A. P., Telles, A. L. S., Malloy-Diniz, L. F., & Palha, A. P. (2020). Mental health: Why it still matters in the midst of a pandemic. *Braz J Psychiatry*, 00, 000–000.
48. Lai, J., Ma, S., Wang, Y., Cai, Z., Hu, J., Wei, N., et al. (2020). Factors associated with mental health outcomes among health care workers exposed to coronavirus disease 2019. *JAMA Netw Open*, 3(3), e203976.
49. (2020). Guidance for surgeons working during the COVID-19 pandemic. The Surgical Royal Colleges of the United Kingdom and Ireland. <https://www.rcseng.ac.uk/coronavirus/joint-guidance-for-surgeons/>.
50. (2020) Management of patients with urgent orthopaedic conditions and trauma during the coronavirus pandemic. British Orthopaedic Association. <https://www.boa.ac.uk/resources/covid-19-boasts-combined.html>.
51. Brindle, M., & Gawande, A. (2020). Managing COVID-19 in surgical systems. *Annals of Surgery*, 27, 20.
52. AAOS Guidelines for Elective Surgery During the COVID-19 Pandemic Daniel K. Guy, MD, FAAOS; Joseph A. Bosco III, MD, FAAOS; and Felix H. Savoie III, MD, FAAOS. <https://www.aaos.org/about/covid-19-information-for-our-members/aaos-guidelines-for-elective-surgery/>.
53. World Health Organization. Algorithm for COVID-19 triage and referral: Patient triage and referral for resource-limited settings during community transmission.
54. Centers for Disease control and prevention. Corona Disease 2019.
55. (COVID-19) Standard operating procedure (SOP) for triage of suspected COVID-19 patients in non-US healthcare settings: Early identification and prevention of transmission during triage. <https://www.cdc.gov/coronavirus/2019-ncov/hcp/non-us-settings/sop-triage-prevent-transmission.html>. Accessed 24 Apr 2020
56. Ayebare, R. R., Flick, R., Okware, S., Bodo, B., & Lamorde, M. (2020). Adoption of COVID-19 triage strategies for low-income settings. *The Lancet Respiratory Medicine*, 8(4), e22.
57. Government of India Ministry of Health and Family Welfare Directorate General of Health Services (EMR Division) Guidelines on Clinical Management of COVID-19. (2020).
58. World Health Organization (WHO). Algorithm for COVID-19 triage and referral: Patient triage and referral for resource-limited settings during community transmission.
59. Ministry of Health & Family Welfare. Guidance document on appropriate management of suspect/confirmed cases of COVID-19. <https://www.mohfw.gov.in/pdf/FinalGuidanceonMangaementofCovidcasesversion2.pdf>.
60. Ministry of Health and Family Welfare. (2020). Containment plan for large outbreaks. Novel Corona Virus Disease 2019. <https://www.mohfw.gov.in/pdf/3ContainmentPlanforLargeOutbreaksofCOVID19Final.pdf>.
61. <https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1612283>. Accessed on 8 Apr 2020.
62. Guidelines for quarantine facilities 2019. <https://ncdc.gov.in/WriteReadData/1892s/90542653311584546120.pdf>.
63. Wax, R. S., & Christian, M. D. (2020). Practical recommendations for critical care and anesthesiology teams caring for novel coronavirus (2019-nCoV) patients. Directives concrètes à l'intention des équipes de soins intensifs et d'anesthésiologie prenant soin de

- patients atteints du coronavirus 2019-nCoV. *Canadian Journal of Anesthesia*, 67(5), 568–576.
64. Royal College of Surgeons. (2020). Good practice for surgeons and surgical teams. <https://www.rcseng.ac.uk/standards-and-research/standards-and-guidance/good-practice-guides/coronavirus/covid-19-good-practice-for-surgeons-and-surgical-teams/>.
 65. Al-Muharrari, M. A. (2020). Testing recommendation for COVID-19 (SARS-CoV-2) in patients planned for surgery—continuing the service and 'suppressing' the pandemic. *British Journal of Oral and Maxillofacial Surgery*, 50266–4356(20), 30164–30169.
 66. Ai, T., Yang, Z., Hou, H., Zhan, C., Chen, C., Lv, W., et al. (2020). Correlation of chest CT and RT-PCR testing in coronavirus disease 2019 (COVID-19) in China: A report of 1014 cases. *Radiology*, 26, 200642.
 67. Udugama, B., Kadhiresan, P., Kozlowski, H. N., Malekjahani, A., Osborne, M., Li, V. Y. C., et al. (2020). Diagnosing COVID-19: The disease and tools for detection. *ACS Nano*. <https://doi.org/10.1021/acsnano.0c02624>. (Epub ahead of print).
 68. Zou, J., Yu, H., Song, D., Niu, J., & Yang, H. (2020). Advice on standardized diagnosis and treatment for spinal diseases during the coronavirus disease 2019 pandemic. *Asian Spine Journal*, 14(2), 258–263.
 69. Center for Disease Control and Prevention. (2018). Ebola. Guidance on personal protective equipment (PPE) to be used by health-care workers during management of patients with confirmed ebola or persons under investigation (PUIs) for Ebola who are clinically unstable or have bleeding, vomiting, or diarrhea in U.S. Hospitals, Including Procedures for Donning and Doffing PPE. <https://www.cdc.gov/vhf/ebola/healthcare-us/ppe/guidance.html>.
 70. Azhari, A., & Parsa, A. (2020). Covid-19 Outbreak highlights: Importance of home-based rehabilitation in orthopedic surgery. *The Archives of Bone and Joint Surgery*, 8(Covid-19 Special Issue), 317–318. <https://doi.org/10.22038/abjs.2020.47777.2350>.
 71. World confederation for physical therapy. Covid -19 information hub. <https://www.wcpt.org/news/Novel-Coronavirus-2019-nCoV>.
 72. Advisory for Physiotherapists and Clinics as preventive measures from ongoing COVID-19 by Indian Association of Physiotherapists.
 73. Bracchi-Ricard, V., Zha, J., Smith, A., Lopez-Rodriguez, D. M., Bethea, J. R., & Andreansky, S. (2016). Chronic spinal cord injury attenuates influenza virus-specific antiviral immunity. *Journal of Neuroinflammation*, 13(1), 125.
 74. Reeve foundation—The Corona virus and spinal cord injury. <https://www.christopherreeve.org/blog>.
 75. Savage, K. E., Oleson, C. V., Schroeder, G. D., Sidhu, G. S., & Vaccaro, A. R. (2016). Neurogenic fever after acute traumatic spinal cord injury: A qualitative systematic review. *Global Spine Journal*, 6(6), 607–614. <https://doi.org/10.1055/s-0035-1570751>. (Epub 2016 Jan 30).
 76. Liang, Z. C., Wang, W., Murphy, D., & Hui, J. H. (2020). Novel coronavirus and orthopaedic surgery: Early experiences from Singapore. *The Journal of Bone and Joint Surgery*, 20, 7.
 77. PMINDIA. https://www.pmindia.gov.in/en/major_initiatives/make-in-india/.
 78. Smith, J., & Judd, J. (2020). COVID-19: Vulnerability and the power of privilege in a pandemic. *Health Promotion Journal of Australia*, 00, 1–3.
 79. The Lancet. (2020). Comment. Global coalition to accelerate COVID-19 clinical research in resource-limited settings.
 80. Daruwalla, Z. J., Wong, K. L., & Thambiah, J. (2014). The application of telemedicine in orthopedic surgery in singapore: A pilot study on a secure, mobile telehealth application and messaging platform. *JMIR Mhealth Uhealth*, 2(2), e28.
 81. Abel, K. A. P. N., Baldwin, K., Chuo, J., Wells, L. M., Ganley, T. D., Kim, A., et al. (2017). Can telemedicine replace the first post op visit for knee arthroscopy in adolescents? *JBJS Journal of Orthopaedics for Physician Assistants*, 5(4), 26.
 82. Holgate, J., Kirmani, S., & Anand, B. (2017). Virtual fracture clinic delivers British Orthopaedic Association compliance. *Annals of the Royal College of Surgeons of England*, 99, 51–54.
 83. Small, S. R., Bullock, G. S., Khalid, S., Barker, K., Trivella, M., & Price, A. J. (2019). Current clinical utilisation of wearable motion sensors for the assessment of outcome following knee arthroplasty: A scoping review. *British Medical Journal Open*, 9(12), e033832.
 84. Board of Governors. In supersession of the Medical Council of India: Telemedicine practice guidelines enabling registered medical practitioners to provide healthcare using telemedicine. <https://www.mohfw.gov.in/pdf/Telemedicine.pdf>.
 85. Kogan, M., Klein, S. E., Hannon, C. P., & Nolte, M. (2020). Orthopaedic education during the COVID-19 pandemic. *Journal of the American Academy of Orthopaedic Surgeons*, 20, 8.
 86. World Health Organisation. (2020). Coronavirus disease (COVID-19) training: Online training. <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/training/online-training>.
 87. Auricchio, F., & Marconi, S. (2017). 3D printing: Clinical applications in orthopaedics and traumatology. *EFORT Open Reviews*, 1(5), 121–127.
 88. Chen, A. F., Kazarian, G. S., Jessop, G. W., & Makhdom, A. (2018). Robotic technology in orthopaedic surgery. *Journal of Bone and Joint Surgery*, 100(22), 1984–1992.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Affiliations

Harvinder Singh Chhabra¹ · Vaibhav Bagaraia² · Swapnil Keny^{3,4} · Kalyan Kumar Varma Kalidindi⁵ · Abhinandan Mallepally⁵ · Mandeep Singh Dhillon⁶ · Rajesh Malhotra⁷ · Shanmuganathan Rajasekharan⁸

Vaibhav Bagaraia
drbagaria@gmail.com

Swapnil Keny
swapnilkeny@hotmail.com

Kalyan Kumar Varma Kalidindi
kalyanvarmambbs@gmail.com

Abhinandan Mallepally
mabhi28@gmail.com

Mandeep Singh Dhillon
drdhillon@gmail.com

Rajesh Malhotra
rimalhotra62@gmail.com

Shanmuganathan Rajasekharan
rajasekaran.orth@gmail.com

- ¹ Department of Spine Service and Medical Director, Indian Spinal Injuries Center, Vasant Kunj, New Delhi 110070, India
- ² Department of Orthopaedics, Sir HN Reliance Foundation Hospital, Mumbai 431202, India
- ³ Grant Medical College and Sir JJ Hospital, Mumbai 400008, India
- ⁴ Sir H.N Reliance Hospital, Mumbai 431202, India

- ⁵ Department of Spine Service, Indian Spinal Injuries Center, Vasant Kunj, New Delhi 110070, India
- ⁶ Physical Medicine Department, PGIMER, Chandigarh 160012, India
- ⁷ J P N Apex Trauma Centre and COVID-19 Facility, Department of Orthopaedics, All India Institute of Medical Sciences, New Delhi 110029, India
- ⁸ Department of Orthopaedics and Spine Surgery, Ganga Hospital, Coimbatore 641043, India