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# Orthopaedic surgery after COVID-19 – A blueprint for resuming elective surgery after a pandemic

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## ABSTRACT

**Background:** The COVID-19 outbreak was fraught with danger and despair as many medically necessary surgeries were cancelled to preserve precious healthcare resources and mitigate disease transmission. As the rate of infection starts to slow, healthcare facilities and economies attempt to return to normalcy in a graduated manner and the massive pent-up demand for surgeries needs to eventually be addressed in a systematic and equitable manner.

**Materials and methods:** Guidelines from the Alliance of International Organizations of Orthopaedics and Traumatology, Orthopaedic Trauma Association, American College of Surgeons, American Society of Anaesthesiologists, Association of perioperative Registered Nurses, American Hospital Association, Centers for Medicare and Medicaid Services, World Health Organization and Centers for Disease Control and Prevention were evaluated and summarized into a working framework, relevant to orthopaedic surgeons.

**Results:** The guiding principles for restarting elective surgeries in a safe and acceptable manner include up-to-date disease awareness, projection and judicious management of equipment and facilities, effective human resource management, a fair and transparent system to prioritize cases, optimization of peri-operative workflows and continuous data gathering and clinical governance.

**Conclusion:** The world was ill prepared for the initial COVID-19 outbreak. However, with effective forward planning, institutions can ramp-up elective surgical caseload in a safe and equitable manner.

## 1. Introduction

The COVID-19 pandemic resulted in dramatic changes to the practice of orthopaedic surgery in healthcare institutions all over the world. As the number of infected and critically ill rose, national and hospital directives were enacted to slow the spread in order to “flatten the curve” and preserve personal protective equipment (PPE) and healthcare facilities for a prolonged battle against the pandemic [1–3]. Many elective surgical procedures were postponed indefinitely or rescheduled for many months later when the situation would hopefully improve [4].

These postponed “elective” procedures are required to alleviate pain, improve function and quality of life and prevent serious complications or disease progression through surgical interventions. With the pandemic stretching into its fifth month now, the number of long-suffering patients has reached critical volumes that will need to be managed sensibly and sensitively once the COVID-19 pandemic improves. While it may seem premature to discuss the post-pandemic future, if nothing else, the COVID-19 pandemic has taught us the importance of

forward planning to mitigate the need for disaster planning at the eleventh hour. A roadmap to resuming elective surgery is outlined below and should be based on the considerations for appropriate timing based on geographical location and disease demographics, COVID-19 diagnostic testing availability, capacity of institutional resources, facilities and workforce, case prioritization, peri-operative care capabilities, data collection, effective clinical governance and rebuilding our readiness for future pandemics.

## 2. General considerations

### 2.1. Timing for resuming elective surgery based on local COVID-19 data

Elective surgery should only be planned if there is a sustained reduction in the number of novel COVID-19 cases in the geographical area managed by the hospital for a period of at least 14 days [5,6]. Additionally, the hospital should also have adequate intensive care unit (ICU) and non-ICU beds, ventilators and PPE to manage both elective

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and emergency cases, in addition to existing COVID-19 patients. The healthcare workforce should be adequately staffed, while maintaining safe duty-hours and healthcare worker well-being.

The maximum estimated incubation period of COVID-19 is approximately 14 days even though 75% of patients develop symptoms within seven days of incubation [7]. As such, a sustained reduction in local cases over 14 days may indicate that local spread has been controlled sufficiently and is on a declining trend [2]. If there are sufficient resources for treating existing and the projected number of potential COVID-19 patients, elective surgery may be resumed gradually while continuously monitoring COVID-19 rates. Specific thresholds for COVID-19 infection rates should be set by the hospital to re-suspend elective surgeries again based on bed capacity, ventilators, PPE and workforce projections.

### 2.2. COVID-19 diagnostic testing availability and policies

Diagnostic testing and isolation of infected patients and healthcare workers remain one of the strongest safeguards against nosocomial transmission [8]. The availability of spare testing kits for surgical patients and healthcare workers and turnaround time should be taken into consideration when preparing to restart elective surgical procedures. Non-urgent elective surgery should only be restarted if there are adequate diagnostic testing kits for both hospital and community-based testing programs.

As the prevalence of asymptomatic or pre-symptomatic patients in the community remains unknown [9,10], rapid testing with real-time reverse transcription polymerase chain reaction [11,12] (RT-PCR) three to five days prior to surgery [13] may be useful to reduce the risk of nosocomial spread and potential post-operative COVID-19 related complications. For patients who present with fever or respiratory symptoms in the post-operative course, institutional COVID-19 testing guidelines should also be established to screen patients using RT-PCR if they are persistently symptomatic despite reasonable interventions.

### 2.3. Personal protective equipment availability and conservation

Institutional PPE requirements can be calculated based on the estimated number of unstable and stable patients and healthcare provider numbers needed to care for them [14]. On average, a single unstable patient will require two rotating shifts of two doctors with patient contact, two nurses with patient contact, two trained observers, one environmental service attendant and one laboratory technician per day. Depending on patient acuity, length of shifts and number of breaks, at least two impervious gowns, 16 gloves, four shoe covers, two N95 respirators and two face shields are required per individual per shift (Table 1). Powered air-purifying respirators (PAPR) may be excluded from calculations as they are reusable. However, turn-around time for decontamination needs to be considered during resource planning. The Centers for Disease Control (CDC) PPE calculator may be used to determine supply needs [14] for maintenance of a stored inventory such

**Table 1**  
Estimated personal protective equipment needed by role per shift.

	Either Gowns or Coveralls Needed		All needed				Either PAPR <sup>a</sup> s or N95 Respirators Needed						
	Disposable Impervious Gowns	Coverall	Glove	Gloves for Examination	Shoe Cover	Fluid Resistant Apron	PAPR	PAPR Shroud	PAPR Battery	PAPR Filter	N95	Surgical Hood	Face Shield
Nurse	2	2	12	4	4	2	2	2	4	2	2	2	2
Doctors	1	1	2	2	2	1	1	1	2	1	1	1	1
Trained Observer	2	0	2	2	2	0	0	0	0	0	0	0	2
Env Services	2	2	12	12	12	2	2	2	4	2	2	2	2
Lab Tech	2	2	4	4	4	2	2	2	4	2	2	2	2

<sup>a</sup> PAPRs: Powered Air Purifying Respirators.

that there is sufficient PPE for 30 days of operations prior to relaxing restrictions on elective surgical procedures. Robust PPE policies [15] should also be in place for healthcare workers and strictly adhered to, to prevent nosocomial transmission of COVID-19 when managing COVID-19 positive cases, patients under investigation (PUI) and non-COVID-19 cases, even as the number of cases decline.

### 2.4. Healthcare facilities and resources

COVID-19 projections for cumulative and daily death rates can be estimated using a mixed effects non-linear regression framework [16]. Health service requirements such as ICU and non-ICU beds, ventilator requirement and lengths of stay can then be projected using a micro-simulation model and available clinical data on clinical practices in COVID-19 patients. The institute for health metrics and evaluation (IHME) provides estimates for all countries with at least 50 cases of COVID-19 cases [17] and can provide guidance for hospital and local authorities on deciding when to resume elective surgery and thresholds for returning to the pandemic mitigation phase based on available and projected healthcare facilities and resources. Phased opening of operating theatres (50% vs 25% vs ambulatory surgery only) may be considered if the projected healthcare facilities are unable to meet the demands of an immediate opening of all operating theatres [5].

Facilities such as ambulatory surgery centers, peri-anaesthesia care units and operating rooms that were previously repurposed or closed during the initial COVID-19 mitigation phase may be converted back to restart elective surgery. For operating theatres that were converted to negative-flow during the COVID-19 pandemic, engineering input needs to be sought to reverse the airflow back to positive pressure theatres. A plan for the cleaning of corridors and walkways along the continuum of care from admission to operating theatre and return to ward is also required in the event of inadvertent contamination.

Scheduling of surgeries will need to be optimized by grouping similar procedures and senior surgeons together to increase efficiency. There may be a need to limit surgical block time assignment for each elective procedure and to extend operating hours into evenings and weekends to accommodate the rapid influx of cases. Perioperative services including diagnostic imaging, sterile processing and therapy services should be readied as well to support the influx of surgical cases. Private facilities and industrial partners may be engaged to provide temporary support in the interim until the hospitals perioperative services are ready.

### 2.5. Healthcare manpower management

Adequate staffing of surgeons, anaesthetists, nurses, housekeeping and support staff are required prior to proceeding with ramping up surgical procedures. Most healthcare workers have already undergone considerable levels of stress and fatigue [18] due to leave suspensions, high-risk work environments and increased domestic obligations due to shuttering of support services such as child care. Additionally,

recovered COVID-19 healthcare workers will require extensive testing to ensure they are no longer infectious, and may be at risk of physical and emotional exhaustion upon return to work [19]. Contingency planning must also be accounted for in the unfortunate event that a healthcare worker cluster were to develop, or a second wave of infection occurs. Surgeons may also want to consider surgical simulation prior to restarting surgery to “shake off the rust”.

Such workforce shortages may be mitigated through recalling of retired or private surgeons as surgical assistants, expedition of training and accreditation of graduating residents and showing flexibility in the operating theatre by allowing nurses and surgical technicians to assist in various surgical roles. By upskilling existing manpower and repurposing skilled veterans, the surgical roles may be fulfilled in a safe and creative manner [20].

### 3. Specific surgical considerations

#### 3.1. Prioritization of cases during the ramp-up period

Prioritization of surgical procedures should be a collaborative process with inputs from orthopaedic surgeons, anaesthetist, nursing staff, hospital management and the facilities management team. The standardization of decision-making factors into an equitable and transparent framework will help to assure the public and prevent ethical dilemmas and moral injury among the decision-making committee. The list of previously cancelled or postponed cases should first be obtained, and patients should be reviewed through telecommunications to determine if they are keen to proceed with surgery during the initial phases of restarting elective surgeries or are keen to further postpone their operations.

An objective priority scoring system such as the Medically Necessary Time-Sensitive (MeNTS) [1] scoring system can be used to prioritize cases based on procedure factors, disease factors and patient factors (Table 2). Procedure factors include operating time, estimated length of stay, percentage chance of postoperative ICU requirement, anticipated blood loss, surgical team size, intubation probability and surgical sites. Disease factors include effectiveness of nonoperative treatment options and exposure risk, impact of two-week and six-week delays on disease outcomes and surgical difficulty or risk. Patient factors include age, lung disease, obstructive sleep apnoea, cardiovascular disease, diabetes, immunocompromise, influenza like illness symptoms and exposure to known COVID-19 positive persons in the past two weeks. Each factor is assigned a score from one to five based on either objective measures or perceived clinical probabilities. The points are then summated to generate a cumulative MeNTS score for comparison among patients, with a higher score representing worse outcomes, excessive risk to personnel and disproportionate resource utilization. As the pandemic continues to evolve, the weightage of each factor may be adjusted to reflect institutional resources, capabilities and local disease patterns to appropriately weigh patient risks and the ethical necessity of optimizing public health concerns.

#### 3.2. Patient communication

Once the patients have been prioritized, effective communication with patients is required to assuage their concerns and provide a clear plan of action for their condition and surgery. As the patients may have a myriad of questions regarding surgery immediately after a COVID-19 pandemic, surgeons should be prepared to discuss topics outside of the surgical procedure. These topics may include case prioritization, COVID-19 testing policies, inpatient policies to prevent nosocomial transmission, PPE utilization, visitation guidelines, post discharge care and follow-up, advanced directives and additional cost requirements [5]. Patients should be warned that any surgical date arranged may be subjected to change depending on the actual COVID-19 situation closer to the surgical date.

#### 3.3. Peri-operative surgical care

As a considerable length of time may have passed since the original surgical date, patients may need to be reassessed prior to planning for surgery. Laboratory tests, radiological findings, comorbidities, symptoms and physical examination findings may be outdated or changed since the last orthopaedic or anaesthetic review. Additionally, previously infected individuals may need to be retested for COVID-19 within six weeks of the rescheduled surgical date as the duration of viral shedding in infected individuals ranged from 8 to 37 days with a median duration of 20 days [21]. Enhanced recovery after surgery (ERAS) protocols (Fig. 1) should be implemented to reduce lengths of stay and improve quality of treatment and patient outcomes.

Pre-operative care of such patients should include a reassessment of their condition and fitness for surgery, a reassessment and re-consenting of appropriate surgical procedure and site, and of the changes in risk and benefits to the patient from delayed surgery. In the immediate pre-operative period, surgical checklists and time-outs may require modification to include patient COVID-19 status, travel history, PPE requirements and availability of special isolation rooms post-operatively.

Intraoperatively, minimally invasive surgical techniques with smaller incisions, reduced surgical times, maintenance of normovolaemia and normothermia and optimized anaesthetic techniques such as short acting spinal anaesthesia or regional blocks with moderate sedation can aid in reducing physical and physiological stresses on the patient so as to aid with rapid recovery of the patient [22].

Post-operatively, recovery is enhanced by optimizing pain control, omission of opioids if possible, post-op nausea and vomiting prophylaxis, encouraging early mobilization, enhancing nutritional and hydration status and reducing unnecessary tubes and drains that may impair physiotherapy and cause complications [23,24]. Patients should optimally be discharged to their own homes to mitigate the risk of COVID-19 transmission and infection by other nosocomial pathogens from post-acute care facilities. If post-operative recovery and rehabilitation is anticipated to be prolonged, discharge to step-down facilities should be arranged expediently to prevent prolonged inpatient stay in acute care facilities.

#### 3.4. Data collection and governance committees

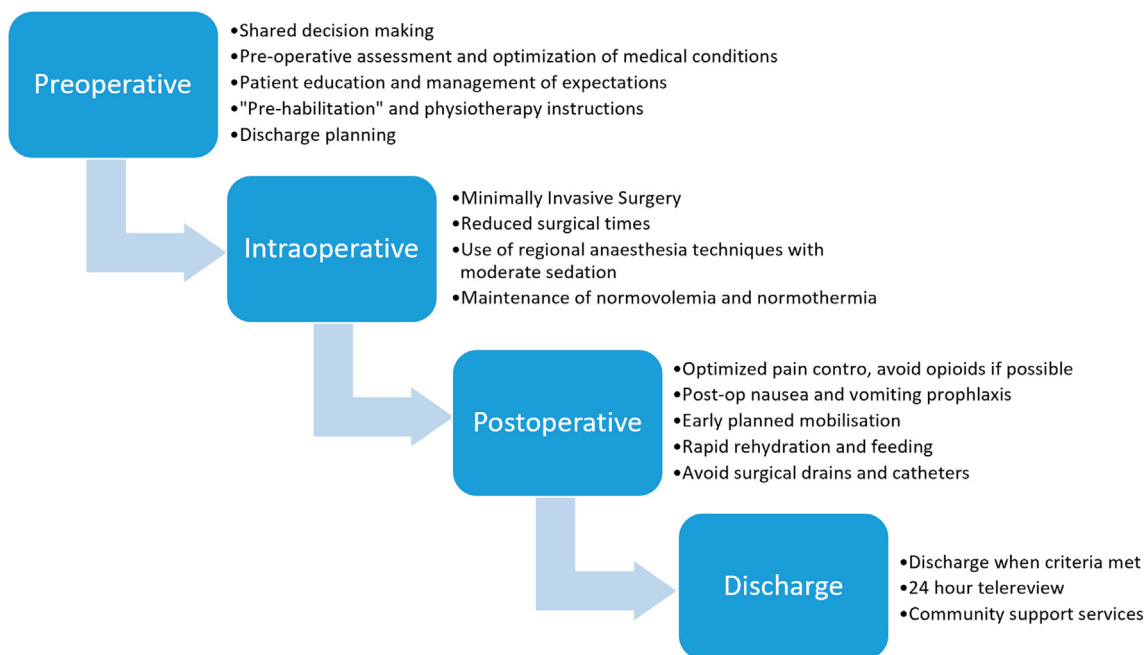
Even as hospitals ramp up their surgical caseloads, data regarding COVID-19 numbers, ICU and non-ICU beds, ventilator and PPE availability, healthcare worker infections, novel disease characteristics, outbreak clusters and local isolation and quarantine policies should continue to be collected and reviewed to anticipate potential shortfalls in resources and to halt elective procedures in the event of sudden surge of new infections. In the initial phases of restarting elective procedures, data regarding surgical complications, mortality rates, readmissions rates, errors and near misses should be collected to study the safety of ramping up surgical caseload. A governance committee consisting of a multidisciplinary team of surgeons, anaesthetists, nurses, hospital leadership and facilities management teams should govern the ramping up of elective surgical procedures especially during the initial phases. Daily huddles may be required to consider increasing or decreasing the caseload based on real-time data before converting to weekly or monthly reviews as the situation improves and stabilizes [5].

### 4. Rebuilding readiness for the next pandemic

A key lesson learnt from the initial COVID-19 outbreak was the need to source for alternative healthcare facilities to manage a surge of critically ill patients or to isolate the asymptomatic but infectious ones. Private-public partnerships should be ratified in order to expand our pandemic preparedness capabilities and tap on the experience and resources of former counterparts [2]. Community care and step-down

**Table 2**  
Medically necessary time-sensitive scoring system factors.

Variable		1	2	3	4	5
Procedure Factors	OR time, min	< 30	30–60	60–120	120–180	≥ 180
	Estimated Length of Stay	Outpatient	< 23 h	24–48 h	≤ 3 d	> 4 d
	Postop Intensive Care Unit Chance	Very unlikely	< 5	5–10	10–25	≥ 25
	Anticipated Blood Loss, cc	< 100	100–250	250–500	500–750	≥ 750
	Surgical Team Size	1	2	3	4	> 4
Disease Factors	Intubation Probability, %	≤ 1	1–5	5–10	10–25	≥ 25
	Surgical Site	None of the following	Abdominopelvic MIS Surgery	Abdominopelvic Open Surgery, Infrumbilical	Abdominopelvic Open Surgery, Supraumbilical	Head and Neck, Thoracic or Upper Gastrointestinal Surgery
	Non-operative treatment option effectiveness	None available	Available, < 40% as effective as surgery	Available, 40%–60% as effective as surgery	Available, 60%–95% as effective as surgery	Available, equally effective
	Non-operative treatment option resource/exposure risk	Significantly worse/not applicable	Somewhat worse	Equivalent	Somewhat better	Significantly better
	Impact of 2 week delay in disease outcome	Significantly worse	Worse	Moderately worse	Slightly worse	No worse
	Impact of 2 week delay in surgical difficulty/risk	Significantly worse	Worse	Moderately worse	Slightly worse	No worse
	Impact of 6 week delay in disease outcome	Significantly worse	Worse	Moderately worse	Slightly worse	No worse
Patient Factors	Impact of 6 week delay in surgical difficulty/risk	Significantly worse	Worse	Moderately worse	Slightly worse	No worse
	Age, y	< 20	20–40	40–50	50–65	> 65
	Lung disease	None	–	–	Minimal (Rare inhaler use)	> Minimal
	Obstructive sleep apnoea	Not present	–	–	Mild/Moderate	On CPAP
	Cardiovascular Disease	None	Minimal	Mild	Moderate	Severe
	Diabetes	None	–	Mild	Oral medication	Insulin
	Immunocompromised	No	–	–	Moderate	Severe
	Influenza Like Symptoms	None	–	–	–	Yes
	Exposure to known COVID-19 positive person in past 14 days	No	Probably not	Possibly	Probably	Yes



**Fig. 1.** Enhanced recovery after surgery protocols.

facilities should also be upgraded such that they may be easily converted into screening centers or community isolation facilities to meet the surge in demand for hospital beds. With regards to PPE and critical resources, such as ventilators, there is a need to expand the supply chain such that a shutdown in manufacturing or logistical support from one region can be mitigated by sourcing from other suppliers. While healthcare workers of this generation are unlikely to forget proper PPE gowning and ungowning procedures, it is important to conduct regular refresher courses to reinforce knowledge and to remind everyone of the importance of safe practice in a pandemic.

## 5. Conclusion

Orthopaedic practice as we know it may be forever changed after the COVID-19 pandemic and over time, surgeons will evolve their practices to adapt to the ever-changing healthcare landscape. To keep ahead of the curve, up-to-date disease awareness, projecting and judicious management of equipment and facilities, effective human resource management, a fair and transparent system to prioritize cases, optimization of peri-operative workflows and continuous data gathering and clinical governance are essential in our road back to restarting elective procedures in a safe and acceptable manner. The world was ill prepared for the initial COVID-19 outbreak, but with effective forward planning, we will not be caught unaware again by the downstream effects of the disease.

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Ethical Approval was waived for the purpose of this review article.

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## Author contribution

Benjamin Tze Keong Ding: Conceptualization, Methodology, Writing - Original draft preparation, Validation, Writing – Reviewing and Editing.

Kelvin Guoping Tan: Data curation, Supervision, Writing – Reviewing and Editing.

Jacob Yoong-Leong Oh: Visualization, Writing – Reviewing and Editing.

Keng Thiam Lee: Supervision.

## Trial registry number

NA.

## Guarantor

Benjamin Tze Keong Ding is the guarantor of the work who accepts full responsibility for the work and conduct of the study, had access to the data, and controlled the decision to publish.

## Availability of data and material (data transparency)

Data and materials are available upon request.

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## Data statement

Due to the nature of the study, no raw data was collected for

sharing.

## Declaration of competing interest

Nothing to declare in this category.

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