


Orthopaedic Surgical Selection and Inpatient Paradigms During the Coronavirus (COVID-19) Pandemic

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Abstract

The novel coronavirus pandemic, also known as SARS-CoV-2, has placed an immense strain on healthcare systems across the entire world. Consequently, multiple federal and state governments have placed restrictions on hospitals such as limiting “elective surgery” and recommending social or physical distancing. We review the literature on several areas that have been affected including surgical selection, inpatient care, and physician well-being. These areas affecting inpatient paradigms include surgical priority, physical or social distancing, file sharing for online clinical communications, and physician wellness. During this crisis, it is important that orthopaedic departments place an emphasis on personnel safety and slowing the spread of the virus so that the department can still maintain vital functions. Physical distancing and emerging technologies such as inpatient telemedicine and online file sharing applications can enable orthopaedic programs to still function while attempting to protect medical staff and patients from the novel coronavirus spread. This literature review sought to provide evidence-based guidance to orthopaedic departments during an unprecedented time. Orthopaedic surgeons should follow the Centers for Disease Control and Prevention guidelines, wear PPE when appropriate, have teams created using physical distancing, understand the department’s policy on elective surgery, and engage in routines which enhance physician wellness.

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Background on Novel Coronavirus and Other Pandemics As They Relate to Healthcare Workers

On March 11, 2020, the World Health Organization declared novel coronavirus (COVID-19) a pandemic.¹ Within 2 weeks, the virus had spread to 330,000 people resulting in 13,700 deaths.² One week later, the surgeon general recommended canceling all elective sur-

geries.³ To manage ensuing issues, such as limited resources and personnel, and preventing the spread of the contagion, several orthopaedic programs have had to modify the way they select patients for surgery and deliver health care.⁴

It is important for orthopaedic care teams to recognize that this pandemic is a constantly changing and fluid catastrophe, so everyone will need to be flexible, adaptable, and ready to pivot rapidly to changing events.

Guidelines are constantly changing, so it is also important that surgeons stay up to date on the latest protocols by using resources such as the American Academy of Orthopaedic Surgeons (AAOS) website and Centers for Disease Control and Prevention website (www.aaos.org and www.cdc.gov, respectively).

The purpose of this review article was to describe many of the modifications which orthopaedic departments can make during the COVID-19 pandemic. Areas discussed include surgical selection, inpatient physical or social distancing, file sharing for online clinical communications, and physician wellness. During this crisis, it is important that orthopaedic programs place an emphasis on personnel safety and slowing the spread of the virus so that the department can still maintain vital functions. Emerging technologies such as inpatient telemedicine and online file sharing applications can enable orthopaedic programs to still function while attempting to protect medical staff and patients from the COVID-19 spread.

Inpatient Surgical Selection and Management

On March 14, 2020, the surgeon general recommended that all elective surgeries be canceled. However, the use of the term “elective” has fallen victim to scrutiny, with notable room for subjective interpretation among surgeons. When considering which surgeries to delay and which ones to prioritize, there are several factors to consider. For clarification, it is important to understand that an orthopaedic surgery can be classified as urgent inpatient (intertrochanteric femur fracture), urgent outpatient (flexor digitorum profundus rupture), elective inpatient, and elective outpatient. The orthopaedic department leadership needs to determine what are the prioritized objectives

about demand for hospital beds, PPE inventory, and other limited resources including intravenous (IV) fluids, ventilators, and personnel.⁵ Targeted reduction on surgeries can be performed for a variety of reasons. Some hospitals may have the objective to vacate inpatient beds. In this scenario, it is important to classify surgeries based on whether they can be performed as outpatient versus inpatient. As such, elective surgeries requiring inpatient admission may be postponed, whereas elective cases that can be accomplished as outpatient are permitted.⁴ When admission is required, valuable resources such as beds, nursing, and supplies are necessary, and their limited stock is depleted. These resources can, instead, be preserved by decreasing elective orthopaedic surgery requiring inpatient admission. If the main concern is shortage of ventilators and anesthesia staff, consideration may be made toward moving urgent outpatient surgery to a local ambulatory surgery center (ASC) to decrease utilization of these resources at the inpatient hospital.⁶

During the COVID-19 pandemic, vital resources such as hospital beds and rooms as well as ventilators may become scarce. This experience in Singapore with the current COVID-19 crisis has already been documented. Chang Liang et al⁴ reported that their department postponed or canceled all nonurgent procedures that needed an inpatient admission. This mainly affected spine surgery, elective pediatric cases, and hip and knee arthroplasty. Other surgeons may use the length of stay (LOS) as a metric to determine which procedures should be performed during this difficult time because longer hospital stays may exhaust more coveted resources and may place patients at increased risk of nosocomial infection.

Gholson et al⁷ performed an analysis of 92,266 patients from 2006 to

2012, reporting the LOS for common orthopaedic surgeries. The authors reported that sport, hand, and some spine procedures typically have less than 1 day stay, whereas arthroplasty ranged from 2.2 to 3.4 days. The authors also identified which comorbidities are associated with increased LOS. They found that increased age, diabetes, general anesthesia, morbid obesity, COPD, poor nutrition, congestive heart failure, non-Caucasian race, and hypertension were correlated with increased LOS. Current times have shown that individuals with more comorbidities are more predisposed to worse clinical outcomes from the coronavirus.⁸ Surgeons may use data such as this to objectively decide which cases are and are not appropriate surgeries, given local resources and pandemic status. In addition, surgeons should optimize modifiable risk factors preoperatively and manage them postoperatively in an effort to decrease LOS.⁷ Orthopaedic surgeons, as always, should make sure that preoperative diabetes mellitus is controlled as best as possible. Additional consideration should be given to use regional anesthesia if possible, consulting a nutritionist and internal medicine consultation for assistance with other preoperative comorbidities.⁷

Orthopaedic Surgical Selection: Elective, Urgent, and Emergency Surgery

The difficult decision to postpone or even cancel surgery may arise when the surgical resources used in both the inpatient and outpatient settings become scarce. However, choosing which surgeries to postpone is not easily determined without some controversy. Some recommendations may be to postpone all surgeries that can be delayed more than 1 month. The Centers for Medicare and

Medicaid Services advises that a surgery can be delayed if it will not cause harm to the patient and they recommend creating a tiered framework for prioritization.⁹ We have categorized major orthopaedic surgeries by how long they can safely be delayed according to the previous studies (Table 1). Deciding which surgeries to cancel may not be as simple as a binary decision (elective versus nonelective). Depending on the phase of the disease locally, orthopaedic programs may move into more of an emergency surgery situation and then move toward allowing elective surgery, then move back into an emergency surgery only situation again. This could occur with quiescent phases, followed by new outbreaks. This second phase phenomenon occurred in Canada with severe acute respiratory syndrome (SARS), whereby a second wave of infection followed the initial recovery.¹⁰

To clarify what previous literature has found regarding urgency of orthopaedic surgeries, we have categorized orthopaedic surgeries into five categories based on priority: priority A (emergency surgery within 24 hours), priority B (urgent surgery within <48 hours), priority C (expedited surgery within 2 weeks), priority D (short-term delayed <3 months), and priority E (long-term delayed >3 months). We recommend moving between these categories in a continuum based on the needs and priorities of the region and hospital system. The surgeries which are routinely performed outpatient are also delineated in this classification system, and orthopaedic departments should also determine whether they are doing inpatient and/or outpatient surgery for each category.

Orthopaedic emergencies are surgeries that should not be delayed. They range from surgeries that should be done immediately (necrotizing fasciitis) to ones that should be done within 24 hours (open frac-

tures). When these surgeries are not done immediately, they may result in loss of life or limb or paralysis.¹¹⁻¹⁸ The American College of Surgeons (ACS) has created a National Quality Improvement Program Participant Use File which describes urgent surgery as not truly emergent but also not elective. Urgent surgeries do not have to be done immediately but should be done when medically stable. Examples include a hip fracture in the elderly, surgical thoracolumbar fracture, or cauda equina syndrome.^{12,19,20}

The term “expedited” has been used to describe procedures where there is no an immediate threat to life or limb.^{11,21} Expedited surgeries are most surgical fractures and surgical tendon ruptures where surgical treatment should not be delayed more than 2 weeks because delay past that point leads to worse outcomes or difficult surgery.^{11,22-25} In addition, delay of surgeries such as delayed closure or flap coverage for open fractures more than 2 weeks can lead to chronic infection or loss of limb.²⁶ Short-term delayed surgeries are procedures that can wait for weeks, but there is literature that supports increased pathology when waiting more than 3 months, such as with ACL reconstruction, myelopathy, or nerve compression with worsening symptoms or muscle weakness.²⁷⁻³⁰ Finally, long-term delayed surgeries are ones that can be delayed more than 3 months, such as a total knee arthroplasty.³¹ Stratification of orthopaedic procedures based on severity and urgency can therefore help conserve and redirect limited resources toward those who may require them more emergently during this health crisis.

As resources become exhausted, guidance from federal or state authorities may be given. It is ultimately the responsibility of the local hospital and orthopaedic department to determine which surgeries can be

delayed to conserve resources. Committees have been created at affected hospitals to stratify urgency of different surgeries, which takes the onus off of individual leaders.³² We prefer a strategy based on the need and supply of tangible resources during different phases of the pandemic (Figure 1). If hospital bed availability is of greatest concern, priority E inpatient surgeries requiring inpatient stays may be postponed.⁴ When all resources are being rationed, all priority D and E surgeries may be postponed. During this phase, attempts should be made at performing urgent and expedited surgeries, which are outpatient, at an ASC or surgical hospital separate from the local inpatient hospital.^{4,6,33} As hospitals move into a recovery phase where resources are more abundant, we recommend performing priority D surgeries before priority E surgeries in case a second phase phenomenon occurs.

Ambulatory Surgery Centers

The Ambulatory Surgery Center Association has released a consensus position that “ASCs can continue to provide safe surgical care for patients whose condition cannot wait until hospitals return to normal operations.”⁶ The Ambulatory Surgery Center Association has outlined a focus on mitigating risk factors, screening for COVID-19, social distancing, prioritizing supply chains for hospitals, and coordinating with local hospitals in each community. Currently, there are some regions where the strain on resources is so high that local ASCs have been closed. In areas where ASCs remain open for clinical care, they can still play a vital role in providing expedited surgical care to alleviate some of the burden on traditional hospital-based surgery systems.

Table 1**Stratified Urgency of Different Orthopaedic Diagnoses and Surgical Procedures for Inpatient and Outpatient Surgeries**

Subspecialty	Priority A Emergency (Within 24 hr)	Priority B Urgent (Within 48 hr)
Trauma	Open fractures Femur neck fracture in the young Pelvic fractures with bleeding ^a Fractures with vascular injury ^a Compartment syndrome ^a Reduction of joint dislocation ^b Necrotizing fasciitis ^a Closed fractures with impending soft-tissue compromise External fixation for complex fractures	Femur neck fracture in the elderly Intertrochanteric femur fracture Talar neck fractures Surgical femur shaft fractures Surgical distal femur fracture Surgical tibia shaft fractures
Spine	Closed reduction of cervical facet dislocation ^a SCI Epidural abscess Epidural hematoma	Cauda equina syndrome
Orthopaedic oncology	Surgical spine tumor with cord compression	Impending pathologic fractures
Foot and ankle		
Miscellaneous	Septic arthritis ^a	
Shoulder and elbow		
Adult reconstruction	Acute arthroplasty infection Reduction of prosthetic joint dislocation	Periprosthetic fracture
Pediatric orthopaedics	Hip fractures and dislocations ^b Supracondylar humerus fractures Slipped capital femur epiphysis Tibia fractures with vascular compromise ^a Open fractures	
Hand	Acute carpal tunnel syndrome Pyogenic flexor tenosynovitis Digit replantation Reduction of joint dislocation	
Sport medicine	External fixation of knee dislocations	

SCI = spinal cord injury

^aSurgery should be done immediately.^bSurgery should be done within 6 hours.

Classification system is based on the priority level of each diagnosis or surgery. Surgeries that are routinely performed outpatient are formatted as bold.

Table 1

Stratified Urgency of Different Orthopaedic Diagnoses and Surgical Procedures for Inpatient and Outpatient Surgeries

Priority C Expedited (Within 2 wk)	Priority D Within 3 mo	Priority E More Than 3 mo
Surgical clavicle fractures Surgical scapula fractures Surgical humerus fractures Surgical radius and ulna fractures Surgical tibia plateau fractures Surgical ankle fractures Pelvis and acetabulum fractures Closure or flap coverage of open fractures Repairable osteochondral fractures	Surgical lumbar disk hernia with radiculopathy Surgical cervical radiculopathy Cervical myelopathy	Spondylolisthesis
Surgical foot fractures		Ankle arthroplasty or fusion
Subacute arthroplasty infection		Shoulder arthroplasty Elbow arthroplasty Knee arthroplasty Hip arthroplasty Spine deformity correction
Pediatric fractures Ligament avulsion repairs	ACL reconstruction	
Surgical hand fractures Tendon and ligament Injuries	Chronic carpal tunnel syndrome Ulnar nerve compression	Trigger finger
Surgical tendon tears	ACL reconstruction	Cartilage repair and regeneration
Acute loose body removal Locked knee from displaced meniscus tear Ligament avulsion repairs	Multiligamentous knee reconstruction Rotator cuff repair in young patients	Chronic rotator cuff tear Superior labral repair
Complete acromioclavicular dislocation	Recurrent shoulder dislocation stabilization	Tendinitis surgery

SCI = spinal cord injury

^a Surgery should be done immediately.

^b Surgery should be done within 6 hours.

Classification system is based on the priority level of each diagnosis or surgery. Surgeries that are routinely performed outpatient are formatted as bold.

ASCs play a vital role in caring for underserved patients because 13.6% of their patients are Medicaid payers, and the average time for surgical visits at ASC surgical visits are 25% to 39% shorter than hospital outpatient department visits.³⁴ These more efficient visits, which have been shown to have lower cost, may use less resources, making ASCs a potentially important player for conservation of medical supplies. Finally, ASCs have been shown to have a low infection rate of 0.484%.³⁵ As major inpatient hospitals prepare to face an increased burden of COVID-19 patients, it may also be beneficial for patients to have their vital orthopaedic surgeries redirected to an ASC, where there are no COVID-19 inpatients being simultaneously cared for.⁶

Society Recommendations

The Orthopaedic Trauma Association recommends that outpatient surgery be considered for fracture fixation, secondary to the fact that inpatient surgery has greater COVID-19 risk to care providers and patients.³⁶ The Orthopaedic Trauma Association has also recommended to limit face-to-face encounters and that in some scenarios, surgery may involve less exposure. The American Orthopaedic Society for Sports Medicine has posted a video giving guidance for athletes who have had their elective surgery postponed.³⁷ The AAOS has released a statement that guidelines should be based on resources including personnel, intensive care unit (ICU) beds, PPE, and respirators.³⁸ They have also recommended a panel including the chief of the ICU, chief of orthopaedic surgery, chief of anesthesia, and head of the hospital to review possible surgeries. The AAOS has also supported guidelines from the Centers for Medicare and Medicaid

Services and the ACS. The ACS has released orthopaedic guidelines stating that during phase 2 (curtail elective) and phase 3 (eliminate elective), many surgeries should still be performed. They list joint dislocations, quad and patella tendon ruptures, aggressive tumors, impending fractures, lacerated tendons, and many fractures as surgeries that should still be performed. They also list surgeries for carpal tunnel syndrome and tendinitis as ones that can wait.³⁹ The American Association of Hip and Knee Surgeons has released general guidelines that patients' waiting for surgery can be managed with other modalities.⁴⁰

Preoperative Screening of Novel Coronavirus

Similar to other coronaviruses, the COVID-19 strain is transmitted primarily as droplets. This fact is especially important when it pertains to airway management of patients with COVID-19. The repercussions of intubating a patient who unknowingly carries the disease can be extreme because the whole surgical team can become exposed to the virus as it becomes aerosolized in an unabated manner during this process. However, if the surgical patient is already known to be a carrier, then precautionary measures can be taken to mitigate further transmission.⁴¹

Because of the gravity of intubating a missed patient with COVID-19, the role of preoperative screening should be given notable consideration. At the time of this publication, there are no established guidelines for preoperative screening for COVID-19. As tests become more rapid and accessible than at the infancy of the pandemic, preoperative screening can certainly become a reality. Currently, the international community has turned to already afflicted countries such as China and Italy for guidance.

Guo et al⁴² recommend to have patients tested for COVID-19 before surgery if available and to place a mask on patients at all times. Another study from several hospitals in China evaluated 34 elective orthopaedic surgery patients who were in the incubation period of COVID-19. These patients unintentionally had surgery without anyone knowing they were infected with COVID-19 before surgery. A large portion of these patients had major complications with a 20.5% mortality and 44.1% rate of ICU admission postoperatively.⁴³ The main utility for identification of patients with COVID-19 before orthopaedic surgery would be to avoid these complications and protect medical staff further.⁴⁴ A paucity in the literature is the reflection of the swift spread of this virus with no clear consensus. Below is a compilation of current recommendations acquired from multiple sources internationally that can be implemented as continued improvements to testing are made:

- (1) All patients and staff are required to wear masks during perioperative contact as if all patients could be positive for COVID-19.^{41,42}
- (2) All but emergent surgical patients should be tested preoperatively for COVID-19 as local resources allow (dependent on facility, Real-Time Reverse Transcriptase-PCR Diagnostic Panels, can provide results in 4 to 6 hours).^{42,44,45}
- (3) Air-purifying respirators (PAPR) for all surgical staff for all patients with COVID-19 + or N95 if none are available.⁴⁶

Physical Distancing of Medical Staff in the Inpatient Setting

During the COVID-19 pandemic, physical or social distancing has been recommended by most state and

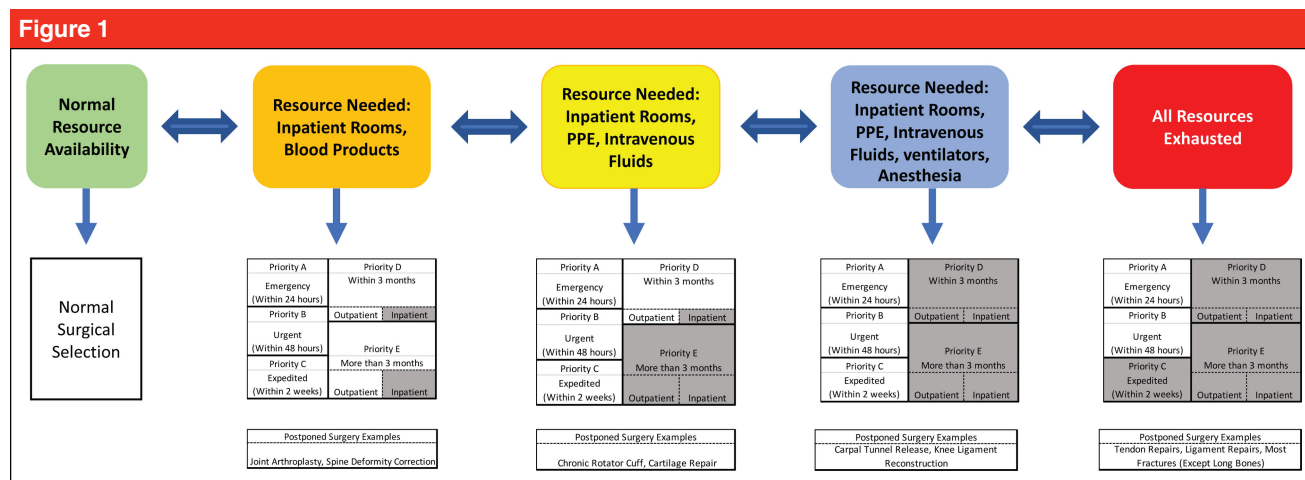
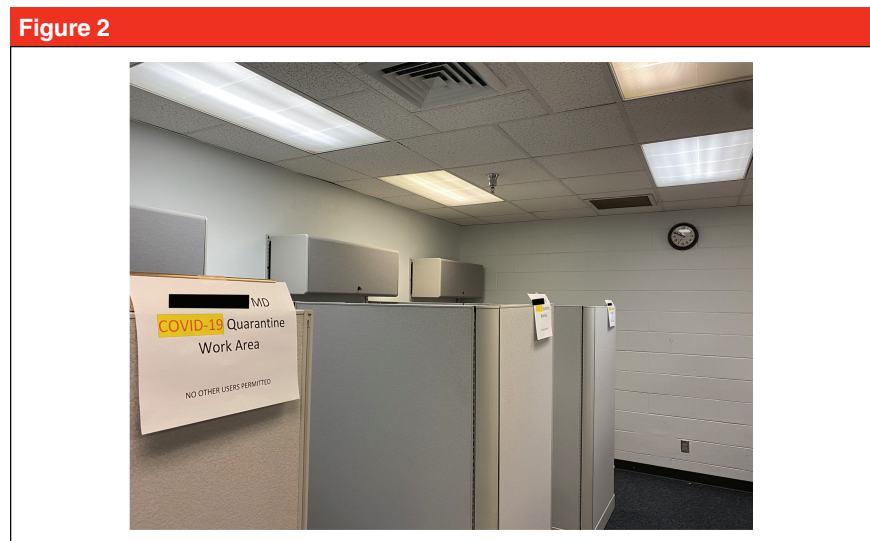


Chart showing resource-based strategy of orthopaedic surgery priorities. Based on which resources are needed, surgeons may prioritize different surgeries. Surgeons may move between phases on a continuum. During all phases, outpatient surgery may be moved to a separate surgery center to mitigate risk and conserve resources at the inpatient hospital. Surgeries that may be postponed in different phases are shaded gray.



Photograph showing the cubicles setup for physician workstations. Each workstation is assigned to a single physician with a clear sign so that no others will use their works station.

federal governments. Social distancing includes cancellation of classes, group outings and large gatherings, flexible worksites (telecommuting when possible), replacing in-person conferences with teleconferences, medical screening and restriction of visitors, and limiting interpersonal contact to greater than six feet.⁴⁷ This is especially important for healthcare

workers who have to be at work and are at higher risk of coming into contact with a COVID-19 positive patient and then spreading the virus to other healthcare workers or teammates. The ACS has released recommendations for maintaining trauma center access during the COVID-19 pandemic. These guidelines include limiting personnel in the

trauma bay to essential staff only, outfitting all trauma employees with appropriate and well-fitting PPE, having redundancies in personnel positions, and converting to virtual meetings whenever possible.⁵ Another consideration is to limit the number of surgeons or assistants in a particular case. Orthopaedic surgeons are typically part of a small, specialized team, and it is critical that the entire team does not become ill simultaneously. This would cripple the ability of the facility to provide effective orthopaedic care to patients.

It stands to reason that any orthopaedic surgeon known to be infected with COVID-19 should be quarantined at home until they are no longer contagious. However, there are several measures that orthopaedic physicians can take that will limit the spread of the virus within their team, should a team member become unknowingly infected. One such measure includes assignment of individual workstations (Figure 2). Coronavirus is estimated to live on surfaces anywhere from several hours up to several days.⁴⁸ Items such as computer keyboards can act as fomites and can theoretically

Table 2**Potential Three-Team Schedule for 15 Medical Personnel (Five per Year)**

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12
Inpatient team												
Trauma chief	PGY 5A	PGY 5B	PGY 5C	PGY 5A	PGY 5B	PGY 5C	PGY 5A	PGY 5B	PGY 5C	PGY 5A	PGY 5B	PGY 5C
Trauma Sr	PGY 4A	PGY 4B	PGY 4C	PGY 4A	PGY 4B	PGY 4C	PGY 4A	PGY 4B	PGY 4C	PGY 4A	PGY 4B	PGY 4C
Trauma Jr	PGY 3A	PGY 3B	PGY 3C	PGY 3A	PGY 3B	PGY 3C	PGY 3A	PGY 3B	PGY 3C	PGY 3A	PGY 3B	PGY 3C
Day consults	PGY 1A	PGY 1B	PGY 1C	PGY 1A	PGY 1B	PGY 1C	PGY 1A	PGY 1B	PGY 1C	PGY 1A	PGY 1B	PGY 1C
Nights	PGY 2A	PGY 2B	PGY 2C	PGY 2A	PGY 2B	PGY 2C	PGY 2A	PGY 2B	PGY 2C	PGY 2A	PGY 2B	PGY 2C
Outpatient team												
Outpatient clinic resident 1	PGY 5C	PGY 5A	PGY 5B	PGY 5C	PGY 5A	PGY 5B	PGY 5C	PGY 5A	PGY 5B	PGY 5C	PGY 5A	PGY 5B
Outpatient clinic resident 2	PGY 4C	PGY 4A	PGY 4B	PGY 4C	PGY 4A	PGY 4B	PGY 4C	PGY 4A	PGY 4B	PGY 4C	PGY 4A	PGY 4B
Outpatient clinic resident 3	PGY 3C	PGY 3A	PGY 3B	PGY 3C	PGY 3A	PGY 3B	PGY 3C	PGY 3A	PGY 3B	PGY 3C	PGY 3A	PGY 3B
ASC surgical resident	PGY 1C	PGY 1A	PGY 1B	PGY 1C	PGY 1A	PGY 1B	PGY 1C	PGY 1A	PGY 1B	PGY 1C	PGY 1A	PGY 1B
Telemedicine clinic	PGY 2C	PGY 2A	PGY 2B	PGY 2C	PGY 2A	PGY 2B	PGY 2C	PGY 2A	PGY 2B	PGY 2C	PGY 2A	PGY 2B
Off-site team												
VA	PGY 2B	PGY 2C	PGY 2A	PGY 2B	PGY 2C	PGY 2A	PGY 2B	PGY 2C	PGY 2A	PGY 2B	PGY 2C	PGY 2A
Pediatric hospital	PGY 4B	PGY 4C	PGY 4A	PGY 4B	PGY 4C	PGY 4A	PGY 4B	PGY 4C	PGY 4A	PGY 4B	PGY 4C	PGY 4A
Off-site hospital 1	PGY 3B	PGY 3C	PGY 3A	PGY 3B	PGY 3C	PGY 3A	PGY 3B	PGY 3C	PGY 3A	PGY 3B	PGY 3C	PGY 3A
Off-site clinic resident	PGY 1B	PGY 1C	PGY 1A	PGY 1B	PGY 1C	PGY 1A	PGY 1B	PGY 1C	PGY 1A	PGY 1B	PGY 1C	PGY 1A
Admin/research resident	PGY 5B	PGY 5C	PGY 5A	PGY 5B	PGY 5C	PGY 5A	PGY 5B	PGY 5C	PGY 5A	PGY 5B	PGY 5C	PGY 5A

ASC = ambulatory surgery center

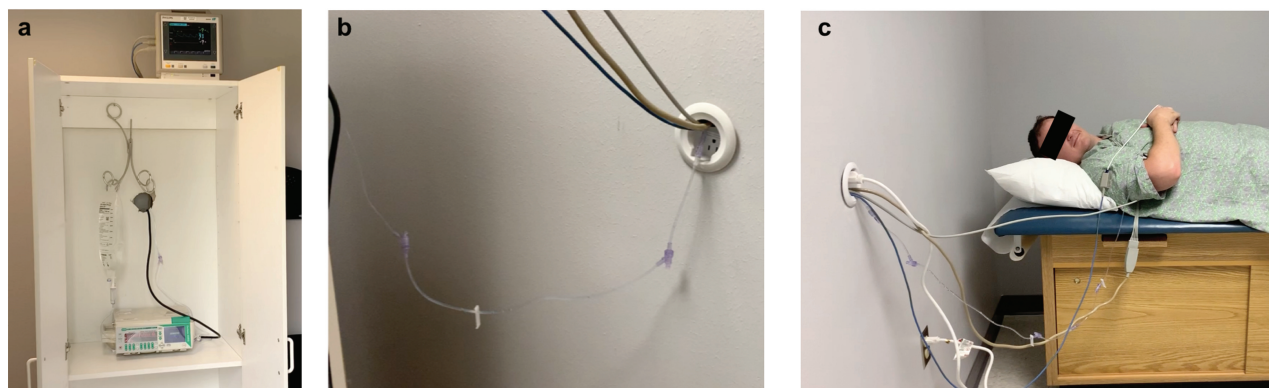
This can be applied to residents, attendings, and/or physician extenders. Each team works 1 week on the inpatient team and then has 2 weeks with no or limited contact in the inpatient setting.

spread the virus if used by more than one person if the appropriate inactivating agents are not rendered. At our institution, we have established individual workstations for our inpatient team of physicians. This can be applicable not only to residencies but also to the entire orthopaedic care teams. These computers and desks are completely separate from any other workspaces designated for the orthopaedic team.

Should a team member become unknowingly infected, he or she can potentially share the contagion to the remainder of the staff by using the communal computers and keyboard. However, by individualizing workstations, we limit cross contamination by eliminating these communal tools between physicians, should any one member become unknowingly infected. This also promotes physical distancing measures because the

workstations are physically isolated from each other.

In addition, many orthopaedic programs are instituting a rotating team schedule⁴ (Tables 1 and 2). As an example, an orthopaedic team of 15 residents would be split into three teams of five. Each team would spend 1 week at a time working to take care of the urgent or nonelective orthopaedic cases and operate from mostly within an inpatient setting,

Figure 3

A, Photograph showing the Bayou box: an intravenous (IV) fluid management system, with ECG, pulseoximeter, and blood pressure monitor which can be accessed outside of a novel coronavirus patient's room. The IV fluids can be secured by closing the cabinet doors and placing a lock. **B**, IV tubing and monitor cables pass through a portal in the exterior wall. **C**, Monitoring cables and IV fluid tubing enters the patient's room through another portal. Video can be viewed at https://www.youtube.com/watch?v=gf_u_CrSCd4.

theoretically sparing the remainder of the residents or staff from a high-viral burden setting. This team then rotates out of the hospital for 2 weeks while the other two teams rotate through. This provides a built-in self-quarantine time of 2 weeks for any team member who may have contracted the virus during their week at the inpatient hospital. This also further limits interactions between members of the program on different teams, thus limiting the spread of the virus among co-residents and decreasing the chances of the entire program being ill at the same time. Although the two other teams are not working in the hospital, they can evaluate patients in the outpatient setting or via telemedicine. This provides for continued patient encounters with little or no risk of COVID-19 transmission to the other teams for 2-week intervals.

Inpatient Telemedicine

Telemedicine has become an increasingly popular method to serve patients while limiting in-person interactions to decrease the spread of

COVID-19. Although telemedicine has become popularized in the outpatient setting across multiple disciplines during the COVID-19 crisis, there appears to be a role within the inpatient setting as well. Specialties such as allergy/immunology, dermatology, infectious disease, and even surgery have already implemented roles for telemedicine for inpatients, with equal and satisfactory results as in-person encounters.⁴⁹⁻⁵² For orthopaedic surgeons, this may include using computers/tablets to interview and examine patients known, or suspected, to be infected with coronavirus. Orthopaedic surgeons should only expose themselves to a COVID-19 positive patient if absolutely necessary, such as to reduce a fracture or dislocation. Inpatient postoperative physical contact on known COVID-19 positive patients can also be limited to things such as dressing changes. Use of this technology as an alternative to in-person encounters is a viable option when the risk of contracting and propagating the virus in a contaminated environment is a real concern.

Nosocomial transmission can also be reduced by minimizing the traffic

in and out of a known coronavirus patient's room. Varia et al⁵³ found that with the SARS outbreak of 2003, the risk of acquiring the droplet-spread virus correlated with the distance to the patient. In addition, inside patient rooms that require contact precautions, not only are the patients contagious but also the medical equipment and accommodations within the room can also become niduses for infection.⁵⁴ A novel way of decreasing this traffic can be the creation of an auxiliary space for medical supplies such as IV poles and associated fluids and medications, which can be accessed physically outside of a patient's room. We have developed a system which decreases PPE usage and exposure to medical staff, as seen in Figure 3. Many of these monitors and fluid management systems are traditionally adjacent to the bedside, requiring nursing staff and physicians to come in close proximity to the patient when they need to be used. In these situations, this can potentiate the spread of highly contagious pathogens from one patient to another when a healthcare personnel needs to perform activities

Table 3**Online Document Sharing Applications for Clinical Communication With Features Listed Such as Cost, HIPAA Compliance, Compatibility, and Signature Capabilities**

Name	Document	Signature Capabilities	Security ^a
Dropbox	Images (.gif, .jpg, .png), .doc, .docx, .docm, .dotx, .dotm, .xls, .xlsx, .xlsm, .xltx, .xltxm, .ppt, .pptx, .pps, .ppsx, .pptm, .potx, .potm, .pdf, .htm or .html, .txt, .rtf, .ico, .zip, .wav, .mp3, .mpg, .mpeg, .avi, .qt, .mov, .MP4, .M4v, .js, .css	Via other applications (ie, DocuSign, HelloSign etc)	HIPAA eligible
Box	Most file types	Via other applications (ie, Docusign, HelloSign etc)	HIPAA eligible
Google Drive/G Suite	Any type	Via other applications (ie, DocuSign, HelloSign etc)	HIPAA eligible
Microsoft OneDrive	Large variety of file types	Via other applications (ie, DocuSign, HelloSign etc)	Plan 2 or business include security/compliance measures. HIPAA eligible.
Hightail	Any type	Yes, may sign PDF, work, Excel, PPT and Rich text files	HIPAA eligible with business level
Amazon WorkDocs	Any type	Via other applications (ie, DocuSign, HelloSign etc)	HIPAA eligible
Hello sign	doc, docx, pdf, ppsx, ppt, pptx, jpg, jpeg, png, xls, xlsx, txt, html, and gif	Yes, reported legally binding per US and European e-signature laws	HIPAA eligible
DocuHub	Built for PDF, but reported capable of other file types including: DOC, DOCX, .XLS, .XLSX, .PPT, .RTF, .TXT, .PNG, .JPG, .JPEG, .GIF	Yes. Reported compliant with legally binding agreements.	No clear documentation of HIPAA compliance.
Adobe sign	Built for PDF, but reported capable of other file types including: DOC, DOCX, RTF, XLS, XLSX, PPT, PPTX, TXT, CSV, HTML, HTM, TIFF, TIF, BMP, GIF, JPG, JPEG, and PNG	Yes, reported meets legal binding standards	Able to be configured for HIPAA compliance ^a
Doc Sign	.doc, .docm, .docx, .dot, .dotm, .dotx, .htm, .html, .msg, .pdf, .rtf, .txt, .wpd, .xps, .bmp, .gif, .jpg, .jpeg, .png, .tif, .tiff, .pot, .potx, .pps, .ppt, .pptm, .pptx, .csv, .xls, .xlsm, .xlsx	Reports e-signature legal agreement compliance	Optional HIPAA compliance

^aMost of the above websites report eligibility for HIPAA compliance with a business associate agreement (BAA). We recommend anyone considering adopting the use of an online filesharing and or signature program, discuss it with his or her information security/compliance office first.

such as changing IV fluids or medications right next to the patient and possibly acquiring the disease inadvertently. The traffic can be avoided, and the contamination of other inanimate objects within a room can be minimized if these fluids and monitors are stationed physically outside the patient's room instead.

Online Document Sharing for Clinical Communications

As we seek to promote physical distancing between providers, the need for online communication increases. The day-to-day operations with our program coordinators, office managers, and administrators involve gathering documents and getting personnel to sign forms. Many people are working from home, so the

documents have to be transferrable from one platform to another. In addition, these documents need to be secure. The transfer of patient information adds the complexity of making sure that the HIPAA compliance has been maintained (Table 3). In addition, with rapid turnover of inpatient teams, it is imperative that there is clear sign-out between teams. Some teams may depend on a patient list that is a shared document, so everyone involved with the inpatient care of these patients will have continuity of care. We collected information about various file-sharing applications listed as the top 10 file sharing sites. We have also described additional e-signature options which may be required for certain documents.⁵⁵

Medical Staff Wellness

With increased regulations on duty hours and mandated wellness modules, overall physician wellness has garnered the attention of graduate medical education over the past decade, but the limitations on other healthcare workers are not so well regulated. Early evidence in the current pandemic situation and experiences from previous outbreak crisis such as SARS have suggested the importance of maintaining healthcare worker wellness. Wellness, in this case, goes beyond limiting exposure to affected patients, but instead, it also includes maximizing one's own immune system while also taking into consideration one's own psychological health.

Table 3

Online Document Sharing Applications for Clinical Communication With Features Listed Such as Cost, HIPAA Compliance, Compatibility, and Signature Capabilities

Compatibility	File Size	Storage	Cost (At Time of Publication)	Free Version	Reference Site
Mac OS 10.10-10.15, iOS 11+, Android 4.4+, Windows 10, Ubuntu 14.04+	Website limit 10 GB, mobile or desktop app no limit	Standard 5 TB, advanced + unlimited	Dropbox business: standard 12.50/user/mo, advanced \$20/user/mo	Trial version	https://www.dropbox.com/business/plans-comparison
Windows 10, most recent 2 macOS, Android (all versions in recent 3 yr), iOS most recent 2 versions	2 GB starter, 5 GB business ad up	100 GB starter, otherwise unlimited	Varies by file type. Word Doc up to 50 MB, presentations 100 MB, spreadsheets 5million cells+18:K	Trial version	https://www.box.com/for-enterprise
Windows 7+, MacOS 10.11+, Android 4.4+, iOS 11+.	Varies by file type. Word Doc up to 50 MB, presentations 100 MB, spreadsheets 5 million cells	30 GB up to unlimited with business/enterprise versions	Basic \$6/user/mo, business \$12/user/mo, enterprise \$25/user/mo	Personal 15 GB storage. Free trial upgraded versions	https://gsuite.google.com/products/drive/
Windows 7+, MacOS 10.12+, iOS 11.3+, Android 6.0+	10 GB	1 TB/user if under 5 users, otherwise unlimited	Plan 1 \$5/user/mo, plan 2 \$10/user/mo, business premium &\$12.50/user/mo	1 mo trial for premium version	https://products.office.com/en-us/onedrive/compare-onedrive-plans?activetab=tab:primaryr2
Windows 7+, MacOS 10.11+, iOS 10.9+, Android 4.4+, Integrated with other cloud services	LITE: 100 MB, Pro: 25 GB, teams: 50 GB, business: 500 GB	Lite 2 GB, otherwise unlimited	Pro \$12/user/mo	Lite	https://www.hightail.com/
Microsoft Windows PCs, Amazon WorkSpaces, and macOS version 10.11 and later Mobile: iOS, Android, and Fire Tablet	5 GB	1 TB per user baseline	Per user, \$5/mo with 1 TB each	Eligible	https://aws.amazon.com/workdocs
Web and mobile App. Windows, iOS, Android. Cloud integrated, based out of Drop Box	40 MB or 500 pages	NA	Unlimited signatures: Pro \$13/mo per user, business: \$40/mo per 5 users	Yes, individual can request 3 signatures month for documents	https://www.hellosign.com/
Web and mobile based. Windows, iOS and android. Cloud integrated, based out of Amazon Web services	<30 MB and <1,000 pages	NA	Fee per user based. 4.99 per month x 12 mo or 6.99 monthly basis	Yes	https://dochub.com/site/about
DesktopMac nd Windows. Mobile. Cloud based	4 MB	NA	Adobe Acrobat Pro with E-Sign. Personal: 14.99/mo/user. Small business (max 9 users) 29.99/mo/user. Larger business: Call for pricing	Trial version	https://acrobat.adobe.com/us/en/sign.html?promoid=C8K12SNQ&mv=other
DesktopMac nd Windows. Mobile. Cloud based	25 MB	NA	Personal: 10/mo limited to 5 requested signatures. Unlimited options: Standard: \$25/user/mo up to 3 users. Business \$40/mo/user up to 3 users. Contact for more users.	Trial version	https://www.docusign.com/

^a Most of the above websites report eligibility for HIPAA compliance with a business associate agreement (BAA). We recommend anyone considering adopting the use of an online filesharing and or signature program, discuss it with his or her information security/compliance office first.

Sleep

Early experiences from the Wuhan outbreak in China showed increased COVID-19 infection in orthopaedic surgeons who experienced fatigue in the 2 months leading up to the outbreak.⁴² Previous studies have also implicated sleep as a player in infection risk. In 1989, Brown et al investigated mice specimens that received a vaccine for the flu virus and showed that sleep deprivation counteracted the effects of the vaccine, making it appear “as though they had never been immunized.”⁵⁶ Many studies since then have tried to replicate the results and further explore the effects of sleep deprivation on immunity.⁵⁷⁻⁶⁰ Benedict et al⁵⁹ showed that in human beings, the antibody response to the H1N1 vaccine was delayed in the first few days in the patients who were sleep deprived but no difference past that initial value. Furthermore, Irwin et al demonstrated that natural killer cell activity was decreased in sleep deprived activity.⁶⁰ Natural killer cells play a role in viral infection by containing early viral replication and destroying infected cells.⁶¹

Aside from immunity, sleep plays a role in mental well-being. Studies from occupational health studies suggest that acute sleep loss is equivalent to alcoholic intoxication with concerns in productivity and decision-making.^{62,63} In addition, a chronic state of lesser sleep deprivation results in similar mental deficits as acute deprivation.⁶² Remaining free of cognitive impairment during this period is critical when you consider paying attention to small details such as donning PPE correctly, recognizing if one is feeling tired from lack of sleep or if this is a part of a constellation of infectious symptoms requiring evaluation, and also to help with clinical comprehension.

Mental Well-being

Sleep is but one important aspect of mental well-being. The previous

SARS epidemic, although not as intensely experienced by the United States, left an impact on China and Canada which can be learned from.⁶⁴⁻⁶⁶ Healthcare workers involved in the epidemic showed over 90% anxiety or depression symptoms during the outbreak or after. Many had residual symptoms even after the disease had retreated. Reasons for the psychologic symptoms included:

- (1) Isolation: Social distancing isolated people from their normal support network. This includes fellow colleagues to discuss and process the current events and normal social activities which people used to relax for work stresses, such as going to a brewery to grab a beer with friends. It gets even worse if you are the unfortunate individual to contract the disease. If you are hospitalized, you will be confined alone within a room, often hours before seeing anyone else because of people trying to limit exposure.
- (2) Stigmatization: There is a lot of fear surrounding the epidemic. Fear of patients can affect the delivery of care. Fear of having the disease can incite people to congest the testing centers. It can also do the opposite in which individuals may downplay symptoms. This second issue could be a particular issue for orthopaedic providers. Healthcare providers may downplay symptoms in an effort to continue to care for patients.
- (3) Guilt: As a healthcare worker, it is not an uncommon battle to balance work and home life. Not only are we risking exposure to ourselves at work every day but also bringing home a certain amount of risk to our families. Our team has taken families into consideration by education about changing clothes and showering before coming in

contact and inquiring about families’ well-being. This not only helps decrease the amount of exposure but again enhances a sense of community.

- (4) Helplessness: Even persons not involved in direct care of infected populations feel the psychologic impact. There has been a push for “nonessential” personnel to be sent home. There is concern that this label implies that a person is not as important as they truly are. The continuation of roles at home gives non-essential individuals something purposeful to do and keep up a normal routine. Change in role, where an individual becomes essential, may be more beneficial. The retrospective evaluation by Maunder et al.⁶⁷ showed that people who were recalled from home into an altered role showed more “psychologic satisfaction.”

There are resources in place to help combat these mental issues that arise from the pandemic. The concept of “psychologic first aid” is a method that is well-documented on. One website with a good checklist about the principles of psychologic first aid can be found at https://www.nctsn.org/sites/default/files/resources/pfa_for_schools_provider_care.pdf.

From these areas of concern our institution has implemented several changes to improve the psychologic well-being and address these issues:

- (1) Maintained communication: Fortunately, this occurs in a time where videoconference and electronic communication resources are in abundance. We have curtailed in-person meetings but have, instead, transitioned to videoconferences with staff and residents to continue to disseminate information and attempt to continue group educational activities to encourage

some normalcy of everyday activities.

- (2) Created shift work or altered roles: As many of our elective services are shut down, surgeons, residents, and ancillary are repurposed to other areas. We have specifically created three resident teams. This leaves one team on the inpatient service at all times (our higher risk exposure group), one team maintaining lower volume, lesser risk services (such as mostly elective services that have reduced volume), and a reserve service (at home, educational and research focused). The staff also have rotations where the inpatient trauma staff rotate to allow coverage if individuals become ill and limit their exposure to the higher risk inpatient setting. In addition, the staff who is not working in the inpatient setting remains isolated in the outpatient setting with a transition to increased use of telemedicine and assistance with administrative duties and supporting the continuation of practices. This continues to allow individuals to work and will create periods of less high-risk exposure for less transmission to self and families. This also increases time for self-care.
- (3) Self-care focus. Shift work increases time to catch up on sleep. Our normal conferences typically occurred at 6 AM, but our videoconferences were shifted to 4 PM to allow people more time to sleep. Staff has recommended good nutrition and exercise, with increased time to allow providers to accomplish both.

Summary

During this global health crisis, it is crucial for orthopaedic departments

to remain plastic and accommodating in light of the ever-changing evolution of the pandemic and its consequential healthcare implications. Modifying surgical selection is paramount to fulfill the needs of the entire health system. Depending on the needs of the local community and the phase of COVID-19 outbreak in a specific area, the surgical selection priorities may change. It remains important that orthopaedic programs place an emphasis on personnel safety and slowing the spread of the virus so that the department can still maintain vital functions. Emerging technologies such as inpatient telemedicine and online file sharing applications can enable orthopaedic programs to still function while attempting to protect medical staff and patients from COVID-19 spread. This literature review sought to provide evidence-based guidance to orthopaedic surgeons during an unprecedented time. Orthopaedic surgeons should follow the Centers for Disease Control and Prevention guidelines, wear PPE when appropriate, have teams created that use inpatient file sharing for clinical communication, understand the department's policy on surgical selection, and engage in routines which enhance physician wellness.

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