

Conclusions: Orthopaedic surgery during the COVID-19 pandemic can be performed safely when medically necessary but should be rare for COVID-19-positive or high-risk patients. Appropriate screening, PPE use, and multidisciplinary care will allow for safe medically necessary orthopaedic surgery to continue during the COVID-19 pandemic.

Level of Evidence: Prognostic Level V. See Instructions for Authors for a complete description of levels of evidence.

Coronavirus disease 2019 (COVID-19) has rapidly evolved as a viral pandemic. Countries worldwide have been affected by the recent outbreak caused by the SARS (severe acute respiratory syndrome)-CoV-2 virus¹. High-density population centers with high mobility patterns, such as the New York metropolitan region, appear to be strongholds of COVID-19 with frequent spread from person to person².

Hospitals and health-care systems are developing into zones of high transmission for COVID-19. As with prior viral pandemics (e.g., influenza A/H1N1, Middle East Respiratory Syndrome [MERS], SARS) health-care workers are at increased risk of contracting COVID-19, which can subsequently reduce staffing and resources for patient care³. The COVID-19 pandemic is different from prior situations because many infected people may be actively shedding virus but are clinically asymptomatic^{4,5}.

Orthopaedic surgical procedures are a mainstay for modern health-care systems, ranging from emergency to elective procedures for chronic conditions. Continuing routine surgical care during this pandemic would place patients and health-care workers of all levels at increased risk for contracting COVID-19 and would consume limited supplies of personal protective equipment (PPE). However, many orthopaedic surgical procedures are life or limb-saving and cannot be postponed in spite of those risks^{6,7}. The purpose of this report is to discuss safe orthopaedic surgery practices during the pandemic and the need to consider alternative strategies for patient care when suboptimal conditions arise. We created a classification system to help guide perioperative decision-making for patients needing medically necessary surgery during the pandemic.

SARS-CoV-2 Virus

COVID-19 is caused by a novel coronavirus (SARS-CoV-2), which was identified for the first time in December 2019 in Wuhan, China^{8,9}. This virus has rapidly spread to >200 countries and territories¹. A characteristic trait of COVID-19 is the relatively long incubation period (the median is 5.1 days, and it usually presents with symptoms within 12 days after infection)¹⁰. A large percentage of infected patients are asymptomatic or have minimal symptoms and increase viral transmission within a population, silently spreading COVID-19 further^{4,5}.

COVID-19 initially was thought to preferentially affect patients >65 years of age with a high rate of morbidity and mortality¹¹. However, younger adults also can be affected with serious illness^{12,13}. In New York City (NYC), many younger patients have been affected, and reports of deaths among people <50 years of age, including health-care workers, have been alarming¹⁴. Further research is needed to understand how age and comorbid conditions affect morbidity and mortality from COVID-19.

Mandates released by health departments and the government have been issued with “stay at home orders,” quarantine measures for infected individuals, closure of nonessential businesses, and travel restrictions to reduce the transmission of COVID-19 and to decrease the national public health burden^{15,16}. While these measures do not prohibit medically necessary office visits, these measures should be supported to limit virus spread. These measures may affect all aspects of ancillary musculoskeletal services, which will greatly affect orthopaedic patient care.

Patient Screening

Current screening recommendations are based on the latest Centers for Disease Control and Prevention (CDC) and World Health Organization (WHO) guidelines and are subject to change because of the rapidly evolving disease¹⁷⁻¹⁹. Because of data regarding asymptomatic spread, screening recommendations are different in regions with a high incidence of infection, such as NYC, compared with regions with low infection rates^{4,5}. All patients undergoing medically necessary orthopaedic surgery procedures should be asked about their personal history over the past 14 days with regard to symptoms such as fever, cough, shortness of breath, respiratory disturbances, pneumonia of uncertain cause, and contact with a person positive for COVID-19²⁰. In areas with a noted community spread of COVID-19, patients have an increased risk of being asymptomatic carriers^{4,5,14}. Travel history is no longer a contributing factor given the widespread nature of COVID-19. Another feature of COVID-19 is the loss of smell and taste early in the disease process²¹. Symptom severity varies widely, with many people who are asymptomatic or are mildly symptomatic people and appear to have a mild cold²⁰⁻²⁴.

Testing for COVID-19 in Low-Prevalence Regions

For high-risk patients needing urgent surgery during the COVID-19 pandemic, we recommend routine screening with a rapid polymerase chain reaction (PCR) test, if available, as close to surgery as possible. Given the limited availability of tests, protocols are evolving for routine PCR testing prior to surgery for patients who live in regions with low to moderate community prevalence. We define moderate and low prevalence of COVID-19 infection as 50 to 100 cases per 100,000 people and <50 cases per 100,000 people, respectively^{25,26}. As tests become more available, we recommend routine testing of asymptomatic patients because of the risk of operating on asymptomatic carriers^{27,28}.

Testing for COVID-19 in High-Prevalence Regions

High-prevalence regions are defined as having an infection rate of >100 cases per 100,000 people^{27,28}. Currently, >100 per

100,000 people are infected with COVID-19 in the New York region and the prevalence of COVID-19 is so high that testing the entire population is not possible²⁹. To maximize the safety of perioperative teams, we recommend treating every patient in a high-prevalence region as being at high risk for COVID-19. With the rapid spread of COVID-19 throughout the world, the highly transmissible nature of this respiratory virus, and the high incidence of asymptomatic carriers, the final recommendation may be that every patient should be treated as if they have COVID-19 once it is widespread in the community.

Safe Orthopaedic Surgery Practices During COVID-19 Pandemic

Patients, surgeons, and all surgical team members are at risk for COVID-19. Considering these risks and challenges facing the public health systems of the world, we have formulated the following recommendations.

Scheduling and Perioperative Team Management

All elective procedures should be rescheduled and delayed. For urgent, emergency, and time-sensitive procedures, standard practices regarding risk-stratification, antibiotic prophylaxis, and sterile practices should be continued. Close monitoring and daily screening of perioperative teams with temperature assessments twice a day is advised to identify early disease and avoid inadvertent viral transmission to patients and team members. We recommend using surgical teams separated physically; the teams should alternate weeks of work to avoid exposure of the entire staff. If one team has a member who tests positive, only the affected team should quarantine. The next available and healthy team would then take over care³⁰. Symptomatic personnel not only should stay home but also should contact their primary care physician and Occupational Health Department.

Orthopaedic Surgery Patients Positive for COVID-19 and in Regions of High Infection Rates

Risks and benefits of orthopaedic surgery should be carefully evaluated for patients who are symptomatic with COVID-19. Because of the high morbidity and mortality from COVID-19, potential delays in surgery may be required, even for otherwise urgent procedures (e.g., a hip fracture in an elderly patient). When it is medically necessary to proceed with surgery, we recommend using an evidence-based approach. Surgery should be performed rarely on COVID-19-positive patients and only in situations in which the risks of surgery are outweighed by the benefits. This most likely would occur in emergency situations (e.g., high-grade open fracture, necrotizing infection, compartment syndrome) or when surgical delay could cause increased morbidity and possibly mortality (e.g., displaced femoral neck fracture, periprosthetic joint infection, perilunate fracture-dislocation).

Analyses of SARS-CoV-1 and MERS viral outbreaks have demonstrated that virus particles are identifiable in the blood³¹. Previous studies have demonstrated that human immunodeficiency virus (HIV) particles are detectable in air samples during surgery with use of power tools³², suggesting that viral

aerosolization is possible during many orthopaedic procedures that involve blood loss and the use of power tools. Intraoperative viral transmission of human papillomavirus from patient to surgical teams from the smoke plume during treatment is controversial^{33,34}. More research is needed to understand how electrocautery and high-speed tools affect the SARS-CoV-2 virus. We advocate for (1) care when using power tools; (2) minimizing use of electrocautery; (3) when needed, using electrocautery at the lowest setting; and (4) aggressive suctioning of surgical smoke to minimize the volume of airborne viral particles.

Positive-pressure ventilation systems combined with a surgical hood and gown, often referred to as a surgical “toga system,” are frequently used during orthopaedic surgeries and are useful for avoiding gross contamination during surgery. Industry data from the time of the initial SARS outbreak in 2003 suggested that surgical togas may offer benefit with regard to preventing the passage of small particles³⁵. It is important to emphasize that the use of surgical togas as respirators has not been approved by the U.S. Food and Drug Administration. With or without toga use, the air environment is best controlled with a negative-pressure ventilation system, which is not available in all operating rooms. Therefore, proper PPE remains critical to the safety of perioperative teams.

PPE must be utilized before, during, and after surgery in order to reduce transmission^{17,18,36-44}. Traffic entering or exiting the operating room should be limited, and all staff entering should be fully protected with PPE. Guidelines from the American College of Surgeons (ACS), CDC, and WHO are being adjusted regularly on the basis of research and may be changed in the future. We support the highest level of protection (including a powered air-purifying respirator [PAPR] or N95 respirator, a face shield or goggles, gloves, boot covers, and an isolation gown) when performing surgery for patients who have or are at risk of having COVID-19⁴²⁻⁴⁴. The CDC specifies that the N95 respirator is preferred to a surgical mask when treating positive patients³. The WHO guidelines also advocate for N95 respirators or PAPR devices during procedures with a risk of aerosolization of viral particles⁴³. Emerging data from Wuhan, People’s Republic of China support orthopaedic surgeon use of N95 respirators when treating COVID-19-positive patients on the ward, in the operating room, and in public hospital locations; not wearing an N95 respirator was found to significantly increase the risk of contracting COVID-19 (odds ratio, 5.2 [95% confidence interval, 1.09 to 25.00])⁴⁵. Importantly, that study also showed a 25% rate of subsequent transmission from the surgeon to others, including family members, colleagues, friends, and patients⁴⁵. Another study from the People’s Republic of China demonstrated decreased infection and mortality rates when an N95 respirator group was compared with a surgical mask group of health-care workers⁴⁶. We advocate for the use of an N95 respirator or PAPR with use of face shields, isolation gowns, boot covers, and gloves for all members during surgery on COVID-19 patients, and these measures are also used for all patients in regions of high infectivity, such as NYC.

Strong communication with the anesthesiology team is vital during surgery on high-risk COVID-19 patients. Close

monitoring of cardiopulmonary function perioperatively is necessary to avoid rapid patient deterioration. CDC guidelines support the use of N95 masks when intubating and extubating patients who are actively shedding viral particles³. New guidelines from the ACS recommend that intubation be performed outside of the operating room (e.g., in the intensive-care unit); the ACS also recommends use of a dedicated operating room for all COVID-19 patients⁴⁷. We recommend that these procedures be performed with the least number of team members present because of the potential aerosolization of viral particles^{48,49}. If the patient has not been previously intubated, regional or spinal anesthesia may be preferred in certain situations⁵⁰. Preoperative chest imaging and close monitoring of oxygen saturation will guide anesthesia teams regarding ideal methods of anesthesia management.

Orthopaedic Surgery for Non-Infected or Asymptomatic Patients

Surgery should be reserved for emergency and urgent situations only, and the decision to proceed to the operating room should be guided by a number of factors. The community prevalence of COVID-19 should factor into guiding treatment in order to avoid straining already stressed health-care resources in regions of high prevalence. Health-care personnel involved with medically necessary surgical procedures should follow ACS and CDC guidelines regarding PPE^{17,18,21,22,33-44}. Because of the risks of viral spread from asymptomatic patients, we recommend the use of an N95 respirator or PAPR when performing surgery for an asymptomatic patient if there is a high prevalence of COVID-19 in the community, such as in NYC^{28,29}. In regions of low prevalence with asymptomatic patients, a standard surgical mask is

TABLE I Classification System for Performance of Only Medically Necessary Surgical Procedures During COVID-19 Pandemic*

Classification	Patient COVID-19 Positivity and Health Status	Community COVID-19 Prevalence	Risk of Surgery Given Patient Status and Community COVID-19 Prevalence	Risk of Disease Transmission to Perioperative Team	Treatment Options	N95/PAPR or Surgical Mask	Additional Recommendations
Class 4	COVID-19-positive, critical illness	All levels	Excessive	Yes	Surgery not advised unless patient improves adequately	N95/PAPR	If patient improves, surgery will be high risk (Class 3)
Class 3	COVID-19-positive, active disease	All levels	High	Yes	Delay if possible; proceed only if life or limb-threatening	N95/PAPR	Risks and benefits of surgery must be decided with a multidisciplinary approach specific to each patient
Class 2A	COVID-19-positive, minimally symptomatic	High	Increased risk	Yes	Delay if possible; proceed if life or limb-threatening; temporize if appropriate	N95/PAPR	Close postoperative monitoring needed; disposition planning needed due to demand for hospital beds
Class 2B	COVID-19-positive, minimally symptomatic	Low or Moderate	Increased risk	Yes	Delay if possible; proceed with surgery if resources allow	N95/PAPR	Close postoperative monitoring needed
Class 1A	Asymptomatic	High	Low	Possible	Delay if possible; proceed if life or limb-threatening; temporize if appropriate	N95/PAPR recommended due to community prevalence	Rapid testing recommended when available to help guide PPE use; discharge as soon as possible, consider outpatient care when appropriate
Class 1B	Asymptomatic	Low or Moderate	Low	Unlikely	Proceed with medically necessary surgery	Surgical mask	Use outpatient facilities when appropriate

*We recommend nonoperative and alternative treatment when appropriate for orthopaedic conditions. In spite of the risks of postponement, delayed treatment should still be considered in certain situations that would otherwise not be acceptable (e.g., delayed surgical fixation of a hip fracture in a patient with active COVID-19). COVID-19 community prevalence is important to consider because of health-care resource limitations. The classification system stratifies patients on the basis of (1) COVID-19 positivity, (2) patient health status, (3) risk of surgery due to COVID-19, and (4) prevalence of COVID-19 in a given region. Analysis of these factors helps to guide PPE use, the safety of surgery, the setting of surgery, and the timing of medically necessary surgery.

TABLE II Recommendations for Medically Necessary Orthopaedic Procedures on Asymptomatic Patients

1. Comprehensive screening protocols for all patients including testing when available
2. Delay all non-urgent surgical procedures
3. Aggressive hand hygiene protocols
4. Strictly follow PPE guidelines, with use of N95 respirator or PAPR for regions of high infectivity for all patients
5. Monitor the surgical and perioperative teams daily for early signs or symptoms
6. Employ use of telemedicine and virtual visits when appropriate for postoperative care
7. Have regular communication with patients and teams
8. Maintain physical distancing between team members

acceptable. Medically necessary outpatient procedures can be safely performed in a surgery center to decrease the burden of care and equipment on hospitals⁷.

When to Operate and Which PPE Is Preferred?

To summarize our recommendations based on the current literature, patients were divided into 4 categories. This classification system is similar to other guidelines^{42,51-53} but adds guidance regarding medically necessary surgical procedures as well as surgery management, such as the timing of surgery, preferred PPE, and ideal setting for surgery for each patient. Details regarding our classification system are shown in Table I.

Alternatives to Initial Hospital-Based Surgery

Standard management of common orthopaedic conditions may not be appropriate during the COVID-19 pandemic, necessitating consideration of alternative management options (see Appendix).

Recommended PPE Not Available: Alternatives to Recommended PPE

During this pandemic, there have been numerous reports of suboptimal PPE use due to lack of reserves, supply-chain limitations, and high global demand, but medically necessary surgery and health care must continue. In situations in which optimal PPE may not be available, alternative options to best protect perioperative teams are necessary (see Appendix).

Postoperative Care: Inpatient and Outpatient Follow-up

In order to minimize COVID-19 transmission following surgery, health-care workers must adhere to CDC guidelines for patient isolation and PPE^{18,36-44}. After surgery, patients should be placed in isolation rooms with strict no-visitor policies.

While standard wound care and antibiotic prophylaxis are recommended, extended antibiotic therapy may be beneficial if an immunocompromised state or bacterial infection is identified. Perioperative multidisciplinary care (provided by orthopaedic surgery, internal medicine, pulmonology, infectious disease, cardiology, nursing, social work, nutrition, physical therapy, and sanitation personnel) will be needed for COVID-19-positive patients to reduce postoperative complications and mortality. Physical and occupational therapy are vital components of recovery after orthopaedic surgery and will need to be implemented as soon as safely possible. The length of stay (LOS) for both infected and non-infected patients during the COVID-19 pandemic may extend beyond the average LOS for a given procedure. Increased LOS may occur not only because of difficulties in arranging rehabilitation center or skilled-nursing center placement but also because of patient morbidities from the COVID-19 illness.

When appropriate, telemedicine can be utilized to allow for remote patient care, thereby reducing patient contact and decreasing demands on the limited supply of PPE^{54,55}. New data suggest that traditional, office-based follow-up may not be

TABLE III Summary of Recommendations for Orthopaedic Surgical Procedures to Be Performed on COVID-19-Positive or High-Risk Patients During the Pandemic

1. Continue above recommendations with regard to hand hygiene, delay of non-urgent surgical procedures, team member monitoring, physical distancing, and postoperative care
2. Use multidisciplinary perioperative management of all patients with COVID-19
3. Minimize operating room traffic
4. Consider regional anesthesia when appropriate
5. Use advanced PPE when treating infected and high-risk patients, including PAPR or N95 respirator with surgical togas when gross contamination is likely
6. Use caution with high-speed power tools and electrocautery during surgery
7. Close cardiopulmonary monitoring is needed
8. Perform intubation and extubation outside of operating room
9. Have a dedicated negative-pressure operating room for COVID-19 patients
10. Consider forming dedicated surgical teams to manage COVID-19 patients in the operating room with supplemental education and rotating schedule
11. Expect extended length of stay


needed for some orthopaedic conditions⁵⁶. We recommend the use of technology to aid in frequent follow-up via telemedicine, video conferencing, and telephone calls to allow for strong patient-to-surgeon communication while limiting direct physician-patient contact and travel to the office⁵⁴. Furthermore, the Centers for Medicare & Medicaid Services (CMS) supports these measures to aid in safe outpatient care⁵⁵. Currently, many forms of communication are allowed by CMS and therefore are also being accepted by some private insurers. However, some forms of communication will not be considered HIPAA (Health Insurance Portability and Accountability Act)-compliant after the pandemic has resolved. We recommend developing a telemedicine approach now that is not only effective in communicating to patients with the use of audio and video but also will be HIPAA-compliant when CMS again requires the prior guidelines for patient privacy.

Summary

Because of the nature of the SARS-CoV-2 virus, the field of orthopaedic surgery must respond according to recommendations for the health of patients, surgeons, and the entire health-care team. Elective surgical procedures should be rescheduled, and inpatient procedures should be shifted to an outpatient setting if possible in order to reduce system-wide stressors on hospitals. We recommend adhering to the ACS guidelines for postponing elective procedures during the COVID-19 pandemic⁵⁷. However, some modifications of these recommendations are likely as we gain greater national experience with management of the viral transmission and how it affects health-care resources.

Orthopaedic surgical procedures for patients infected with COVID-19 should be conducted on the basis of a systematic evaluation of each patient's COVID-19 positivity, the patient's health status, the community COVID-19 prevalence, and the nature of the patient's pathology. Orthopaedic surgeons will need to be adaptable as COVID-19 may compel us to use alternative approaches compared with our typical practice with full resources. Tables II and III summarize our recommendations regarding orthopaedic surgery during the COVID-19 pandemic. Orthopaedic surgery should be performed for the properly indicated conditions during this pandemic, but careful perioperative planning is required to maximize the protection of patients, surgeons, and all perioperative team members.

Appendix

 Supporting material provided by the authors is posted with the online version of this article as a data supplement at [jbjs.org \(http://links.lww.com/JBJS/F891\)](http://links.lww.com/JBJS/F891). ■

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