# The Orthopaedic Trauma Service and COVID-19: Practice Considerations to Optimize Outcomes and Limit Exposure

*Daniel J. Stinner, MD, PhD,[a] Christopher Lebrun, MD,[b] Joseph R. Hsu, MD,[c] A. Alex Jahangir, MD, MMHC,[a] and Hassan R. Mir, MD, MBA[d]*

**Key Words** COVID-19, practice considerations, coronavirus, pandemic, orthopaedic, practice

(*J Orthop Trauma* 2020;00:1–8)

## INTRODUCTION

On March 11, 2020, the World Health Organization (WHO) declared a global pandemic as the spread of COVID-19 was seen in more than 100 countries around the world.[1] Despite only a few confirmed cases in the United States, clustered in Washington and New York States, this declaration set into motion a series of CDC recommendations that included appropriate hygiene, the use of personal protective equipment (PPE), and social distancing. Despite these measures, however, exponential spread and diagnosis has occurred, overwhelming hospitals around the country. As of April 3, 2020, there were more than 240,000 confirmed COVID-19 cases, including more than 6200 deaths.[2] Although health systems have primarily focused on ventilator and PPE availability with most elective cases being canceled, the orthopaedic trauma community is still operating, tending to the fractures that still occur during this global pandemic. With little guidance provided by the CDC and WHO, the following hopes to summarize and provide relevant information to the practicing orthopaedic traumatologist in maximizing outcomes while limiting exposure when operating during the COVID-19 pandemic.

## COVID-19: BACKGROUND

COVID-19 is the disease caused by SARS-CoV-2, which has similarities to the virus that caused the SARS outbreak from 2002 to 2003.[3] Viral spread occurs through introduction to the mucous membranes through respiratory droplet and/or direct contact with a contaminated object, which is then introduced to an area that can accommodate infection (ie, touching nose/mouth).[3] Recent work has demonstrated that SARS-CoV-2 may also be transmitted as an aerosol,[4] which has been shown to occur when making surgical incisions, using electrocautery of bleeding, drilling/reaming of bone, and during wound irrigation,[5] which are all common components of most orthopaedic trauma procedures. Again, although this is predominantly considered a disease transmitted through the respiratory system, a recent study has demonstrated that SARS-CoV-2 RNA has been detected in plasma and lymphocytes, increasing the concern for viral spread during both blood transfusions and surgical procedures where the virus may be aerosolized outside of the respiratory system.[6]

An additional concern with the spread of the SARS-CoV-2 virus is the potential evidence of transmission in asymptomatic patients.[7] As health care workers, this is of utmost concern as we can unknowingly spread the virus. In a recent report from Wuhan on orthopaedic surgeons infected with COVID-19, many were felt to be exposed in the hospital or clinic setting, and then, several further exposed others (family/friends, colleagues, and patients) to the virus.[8] As one of the few remaining surgical specialties that remain active, asymptomatic spread among the orthopaedic trauma service in its activity in various clinical settings remains an essential concern. The following are orthopaedic trauma service, outpatient fracture clinic, and inpatient surgery considerations for helping to minimize the spread of the virus and optimize outcome in our patients.

### Orthopaedic Trauma Service Considerations

There have been various protocols implemented across individual institutions to both minimize the spread of SARS-CoV-2 and protect the workforce. The overall goal is to create a system-sustaining model that allows for appropriate resource allocation to provide optimal patient care, while minimizing viral spread to other patients and members of the treatment team. For example, Schwartz et al[9] describe the creation of a two-team system where each team functions completely independent of one another with one team working in the hospital and the other working remotely. In this system, the teams are designed to transition every other week, allowing for the appropriate incubation period for the viral symptoms to be present before the return to hospital. Therefore, symptoms that arise during the time away from the hospital and direct patient contact allow for recognition, quarantine, and by default, minimal exposure to the rest of the team.[9] Given that exposed individuals may remain asymptomatic for up to 14 days,[10] consideration should be given

Accepted for publication April 9, 2020.

From the aDepartment of Orthopaedic Surgery, Vanderbilt University Medical Center, Nashville, TN; bDepartment of Orthopaedics, University of Maryland, Baltimore, MD; cDepartment of Orthopaedic Surgery, Orthopaedic Surgery, Atrium Health, Charlotte, NC; and dDepartment of Orthopaedic Surgery, University of South Florida, Orthopaedic Trauma Service, Florida Orthopaedic Institute, Tampa, FL.

The authors report no conflict of interest.

Reprints: Hassan R. Mir, MD, MBA, Department of Orthopaedic Surgery, University of South Florida Orthopaedic Trauma Service, Florida Orthopaedic Institute, 5 Tampa General Circle, Suite 710, Tampa, FL, 33606 (e-mail: hmir@floridaortho.com).

to establishing a 3-team approach where one team is working in the hospital involved in direct patient care, while the other teams are rotating through 14 days away from the hospital essentially working remotely in a cyclical "quarantine" between episodes of direct patient care. This team-based system approach can also be used for trainees and midlevel providers to limit exposure and spread of the virus. The authors understand that it is difficult to "work remotely" in our line of work, but minimizing unnecessary contact with colleagues and patients can help minimize the spread of the virus. Many facilities have also closed lounges and workspaces to promote social distancing of workforce members.

Videoconferencing provides an excellent opportunity to continue clinical care and surgical education and communicate with team members while practicing social distancing to minimize the spread of the virus. It has become standard practice at each of the author's institutions to use video or teleconference for all morning rounds and other education events that previously occurred in person. Although consultation for musculoskeletal conditions in the emergency department and inpatient setting must continue, many of the author's institutions have been performing electronic consultations for conditions that do not require in-person evaluation; however, in those circumstances, the consulting service and patient/family are called, and proper documentation of the assessment and plan including follow-up care is mandatory. Limiting the number of personnel assisting in hospital call, in clinics, and in the operating room is essential to minimizing workforce exposure and maintaining service capabilities.

## Fracture Clinic Considerations

As orthopaedic trauma clinics are often busy, drawing patients from well beyond the immediate surrounding area, we have the potential to spread the virus unknowingly across our local region if we are an asymptomatic carrier of the virus. To mitigate this, several measures can easily be implemented in clinic to minimize unnecessary follow-up, thus minimizing the risk of potential exposure. Considerations should be made to limit in-person clinic visits to the following: immediate postop visit for suture removal (when not able to be removed elsewhere or resorbable sutures are not used), fracture reduction check for nonoperatively managed fractures that had a reduction and splint or cast applied, new acute fractures, patients with potential or concern for complications, and those patients with a potential weight-bearing status change that requires x-rays and/or cast removal before making the decision.[11] Furthermore, when feasible for this last subset of patients, x-rays can be ordered with the patient obtaining them at a location close to their home with subsequent review and treatment recommendations provided during a telehealth visit eliminating the need for an in-person clinic visit. Additional surgeon-controlled variables such as the use of resorbable suture and removable splints described in more detail later can also be used to minimize clinical follow-up during the pandemic.

Additional measures in clinic settings may include screening all persons (providers, staff, and patients) before entering the building with questioning and temperature, excluding additional visitors, and separating teams that are appropriately streamlined to include only essential personnel into different clinic zones. Waiting rooms can be modified to allow social distancing, and when not feasible because of waiting room size, patients should have the option to wait in their car or another less crowded location and be called when ready for their in-person visit. Finally, appropriate PPE should be used for all visits (eg, masks, gloves, and goggles), all examination rooms and workstation areas should be meticulously cleaned, and hand washing or sanitizing between each patient encounter and throughout the day is a must.

When patients present to the clinic with fractures that truly require operative fixation to avoid significant morbidity due to a delay of greater than 30 days, surgeons should be aware of their local resources and plans for how to optimize care for these individuals. Several cities in the United States are already consolidating care to designated hospitals (for inpatients) or surgery centers (for outpatients) for fracture care. Most patients presenting to the outpatient clinics that have surgically indicated fractures have injuries that can be managed in outpatient settings. Ideally, patients undergoing surgical fracture care would be screened and tested for COVID-19 preoperatively (as close to surgery as possible) irrespective of the surgical setting to minimize exposure.[8] If a patient tests positive, then consideration should be given to managing the fracture nonoperatively or delaying surgery until the patient has cleared the virus when appropriate. Despite these recommendations, some patients with COVID-19 will require operative fixation of their injuries, and it is imperative that the surgical team optimizes the treatment plan to minimize patient morbidity while also minimizing potential spread of the virus.

The use of telehealth has grown exponentially in recent weeks to minimize the spread of SARS-CoV-2.[12] Previous work has demonstrated successful use of telemedicine in orthopaedic trauma patients, achieving high level of patient satisfaction comparable with in-person clinic visits with the benefit of no patient in the telemedicine group taking time off from work for the visit.[13] Various publications have demonstrated successful use of telemedicine in other specialties, and it has developed a clear roll during the COVID-19 pandemic.[12,14] Several barriers have existed preventing the adoption of telehealth into standard orthopaedic trauma care, but the likely duration of this pandemic will contribute to our willingness to adopt telehealth into our practice when the pandemic resolves. In addition, rapid approval of medical licenses for surrounding states during this pandemic and improvement in billing for telehealth clinical visits has likely contributed to more mainstream adoption.[15]

Now, more than ever, it is important to review clinic schedules to ensure only patients who need in-person follow-up are seen in clinic, while the remaining patients can either be deferred until after the COVID-19 pandemic resolves or be evaluated through telehealth to minimize potential risk of exposure and further spread of the virus. Also, remember that during the COVID-19 pandemic, normal billing procedures with a GT (synchronous telecommunication/audio and video) and CR (catastrophe/disaster related) modifier and POS 02 (Place of Service regardless of physician or provider location,

ie, telehealth) can be billed for every telehealth visit, but the practitioner should refer to their local insurance company or institutional regulations for specific guidelines.

## Inpatient Surgery Considerations

Fortunately, for many institutions, the trauma burden has decreased slightly because of initial social distancing and stay-at-home recommendations allowing for the planning and adoption of preventative measures to protect both the health care team and the patient. Many hospitals have now limited inpatient surgery to emergent or urgent cases, which in some systems include those fractures that truly require operative fixation to avoid mortality or significant morbidity due to a delay of greater than 30 days (Figs. 1 and 2). Consideration should be given to the segregation of emergency cases into COVID-19 confirmed or unknown operating rooms, and COVID-19 negative operating rooms. In patients where surgical intervention cannot be delayed until COVID-19 testing results are returned, consideration should be made toward treating the patient as COVID-19 positive until test results are returned. Although this will result in increased use of PPE, it may decrease the nosocomial spread of the virus both to health care workers and other patients. Unfortunately, there are documented cases of nosocomial spread of SARS-CoV-2 in orthopaedic trauma patients making strict protocols for infection control of paramount importance.[16]

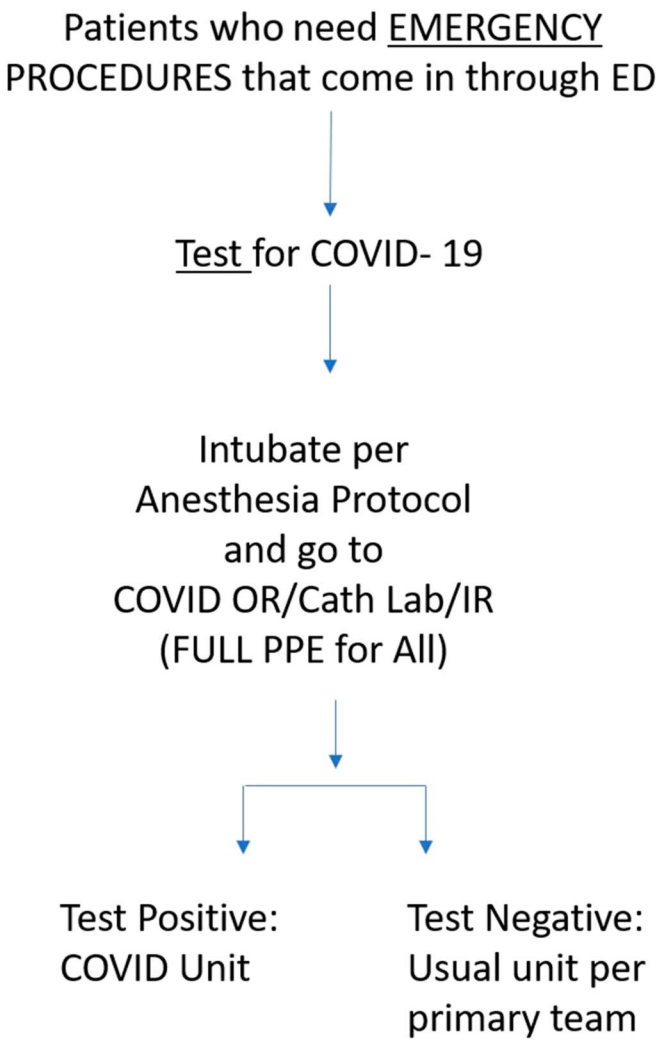


**FIGURE 1.** Example of an algorithm from one institution for emergency surgical procedures in trauma patients presenting to the emergency department during the COVID-19 pandemic. Note that all patients are considered COVID unknown and treated as such until test results are confirmed.

Owing to the mechanism of spread of the virus, there is concern for virus transmission to the operating room personnel. Each case should be performed with a streamlined team of only essential personnel, which at some author's institutions includes a maximum of one assistant. In addition, consideration should be given to discouraging sales representative presence in the operating room unless critical for patient care to minimize potential virus exposure. Owing to the potential for aerosolizing of the virus, strict adherence to newly established protocols is of paramount importance (Table 1). When possible, intubation and extubation should be performed either in a separate dedicated room for intubation/extubation or in the operating room without the surgical team present. Normally, within the operating room, the direction of airflow should be from the operating room to the hallway (positive pressure) to minimize contamination of the surgical field.[17] In some hospitals, there are operating rooms with reversible airflow or pressure, whereas others have positive-pressure rooms with a negative pressure anteroom. Aerosol-generating procedures on COVID-19–suspected or –confirmed positive patients should ideally take place in negative pressure rooms,[18] but this negative pressure can put patients who are having surgery at an increased risk of surgical site infections. A risk assessment should be performed to determine whether the patient's surgery can be postponed until COVID results return negative or positive patients are no longer infectious. Conversion of the operating room to negative pressure will likely require consultation with the operating room engineering and maintenance team. In addition, it is important to evaluate whether altering the pressure to be negative in one or more operating rooms will affect the air balancing in adjacent areas.[18]

If it is determined that a negative pressure room will be used for a surgical procedure, keep the doors to the operating room closed and minimize traffic into and out of the room. The procedure should be performed with the fewest people possible to optimally perform the procedure in the surgical suite. This should require limiting resident and fellow involvement. Owing to the elevated risk of virus aerosolization during intubation and extubation, consideration should be given to regional/peripheral nerve blocks or spinal/epidural anesthesia whenever possible with the patient's nose and mouth covered with a surgical or N95 mask. If the patient is not already intubated but it is necessary for surgery, intubation and extubation should be performed either in a separate dedicated room for intubation/extubation or in the operating room without the surgical team present. After a procedure on a COVID-19–suspected or –confirmed patient, the operating room should be left vacant, time dependent based on air changes per hour for your operating room ventilation system,

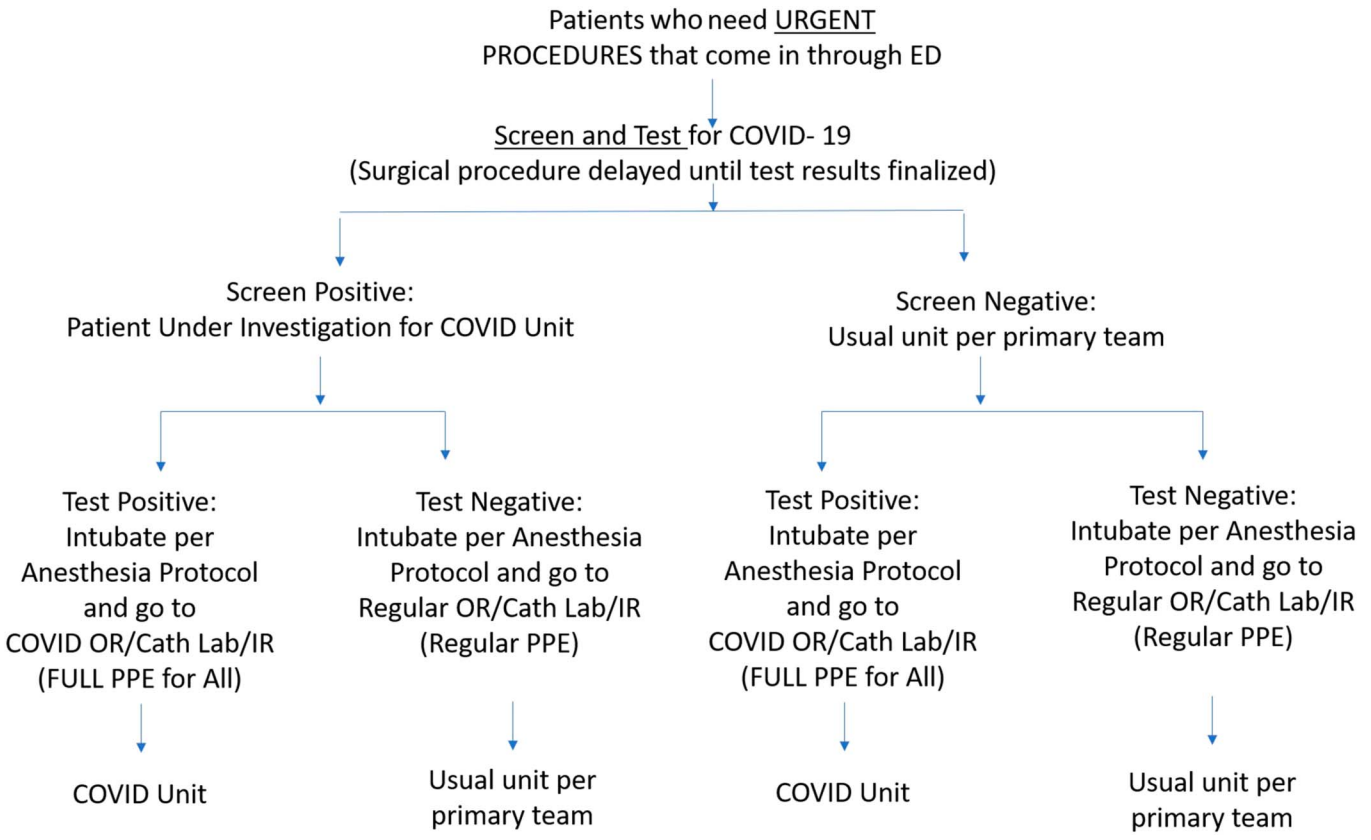


**FIGURE 2.** Example of an algorithm from one institution for urgent surgical procedures in trauma patients presenting to the emergency department during the COVID-19 pandemic. Note that all urgent surgical trauma patients are initially screened and tested with surgical intervention delayed until test results are finalized.

while the OR air exchangers clear any airborne contaminants that may remain.[19–21] These air exchanges that remove airborne contaminants should occur before anyone who is not wearing respiratory protection enters the room and before environmental cleaning is done.[17,22,23] In addition, some authors have also advocated for the establishment of zones or levels of protection, so that personnel are fully protected when at the point of maximal potential for exposure in the operating room.[23]

Given the concerns for global shortages of PPE, rationing of PPE has occurred at many medical facilities, leading to a growing concern for appropriate personal protection (Table 1). Although standard surgical masks may provide enough protection for the prevention of influenza and other viral respiratory infections in health care personnel,[24] they may not be as effective as the N95 respirator at preventing infection with SARS-CoV-2.[8,25] Standard surgical masks and respirators are usually assigned a "fit factor," which is a quantitative estimate of the concentration of a substance in the ambient air to the concentration of the substance in the respirator when it is worn.[26] Most standard surgical masks have a fit factor between 2.5 and 9. Adding additional surgical masks, that is, wearing multiple masks, can increase the fit factor, but the fit factor is still less than 15 even when 5 masks are worn.[27] In addition, taping the surgical mask to your face improves the fit factor by nearly a factor of 2,[28] but regardless

**TABLE 1.** Considerations for PPE for Orthopaedic Surgeons

| Confirmed Non-COVID-19 | COVID-19 Status Unknown | COVID-19 Positive |
|---|---|---|
| Minimum | Minimum | Minimum |
| Standard PPE (surgical masks, eye protection, and gown) | Standard PPE | N95 respirator with full-face shield or surgical hood |
| | Additional PPE considerations for possible aerosolizing orthopaedic procedures[5] | |
| | N95 respirator with full-face shield or surgical hood | |

of these adjuncts, they do not meet the qualification of a "respirator" and fall far short of the N95 respirator that has a fit factor of 100. An adjunct that is included in the algorithm shown in Fig. 1 is the use of a surgical hood. It is important to note that the surgical hood has a fit factor similar to that of a standard surgical mask, but it does cover the entire face and when used in conjunction with a surgical mask or N95 respirator can provide an additional level of protection when operating on high-risk patients.[29] The N95 and hood must be donned in an area that is free of aerosols to provide protection; failure to do so may actually increase risk for exposure to the wearer.[23] Specifically, if using a surgical hood, it is imperative to not connect the hood to the battery, turning the system on, until after fully gowned to limit surrounding air flow and potential spread of the virus if in a contaminated environment.[30]

Given the concern for continued availability of PPE, considerations and recommendations have been made on the reuse of N95 respirators. In several of the author's institutions, the N95 respirators are only being used for SARS-CoV-2 positive patients or by members of the operative team for high risk, aerosolizing procedures in SARS-CoV-2 unknown patients. In many of these institutions, the N95 respirators are being reused for several days unless they are soiled or contaminated. It is important to remember that reuse of a contaminated N95 respirator puts both the user and others at risk of potential spread of the virus. There are significant ongoing efforts to identify safe and effective ways to disinfect N95 respirators to allow reuse of N95 respirators to include the use of ultraviolet light and heat protocols.[31–33]

It is common practice for most trauma incisions to be closed with nonabsorbable suture or staples. Unfortunately, these often require a health care professional to remove them. To minimize the need for early postoperative follow-up during the COVID-19 pandemic, some of the authors have begun using absorbable suture for skin closure when possible to eliminate the need for an early postoperative visit for suture or staple removal. In cases where sutures or staples are preferred, the patients can be sent home with a suture or staple removal kit with written instructions and links for how to do it themselves (Table 2). Patients being discharged to institutions where sutures can be removed (eg, skilled nursing facilities, inpatient rehabilitation centers, nursing homes, and prisons) may also have their sutures removed by providers at those facilities. Successful removal can be confirmed through a telehealth visit.

In cases where splints were usually placed for "soft-tissue rest" until suture removal, patients are being placed in well-padded soft dressings and removable splints, so that the first postoperative follow-up visit for can easily be performed through telehealth. However, patients who require a reduction with splinting or cast placement must still be seen in-person to ensure maintenance of alignment and to transition to the next phase of recovery when appropriate.

One of the largest impacts one can have on the treatment of our patients involves clinical decision making and surgical planning. This begins by deciding if, when, and how to operate on a patient. Many factors must be considered, but of paramount importance is ensuring optimal patient care. It is important to recognize SARS-CoV-2–associated risks to both to patients, resources, faculty, and staff as well as weighing the morbidity associated with any delay or alteration in treatment plan. Three cases are presented demonstrating a change in practice to minimize patient morbidity and potential spread of SARS-CoV-2.

## Case 1

A 23-year-old man with developmental delay presented during the COVID pandemic with a syndesmotic screw that had back out and was now exposed, 14 months after ankle fracture fixation (Fig. 3). The surgeon's preference would have been screw removal in the operating room before the COVID pandemic. In an effort to minimize the risk of exposure to the patient, while conserving critical resources, the syndesmotic screw removal was performed in the emergency department under sterile conditions with light sedation. The wound was closed with absorbable suture, and the patient was sent out on a short course of oral antibiotics. A telehealth visit was scheduled in 3 weeks.

## Case 2

A 71-year-old male cyclist was struck by a motor vehicle sustaining a severe brain injury with cerebral edema, multiple facial fractures, and a right anterior column posterior hemitransverse acetabular fracture (Fig. 4). Secondary to previous activity level and dome impaction, the operative plan was for limited internal fixation followed by delayed total hip arthroplasty following the COVID pandemic in an effort to minimize potential spread of SARS-CoV-2 and optimize resource allocation. Pre-COVID-19, the surgeon's preference would have been for a limited open reduction and internal fixation immediately followed by total hip arthroplasty in the same setting. Intraoperative stress examination after limited fixation demonstrated a stable hip.

**TABLE 2.** Patient Resources for Home Suture or Staple Removal

| |
|---|
| Suture removal links |
| https://www.youtube.com/watch?v=-qqQaiCJrCM |
| https://www.wikihow.com/Remove-Stitches |
| Staple removal links |
| https://www.youtube.com/watch?v=jD18WeritMY |
| https://www.wikihow.com/Remove-Surgical-Staples |

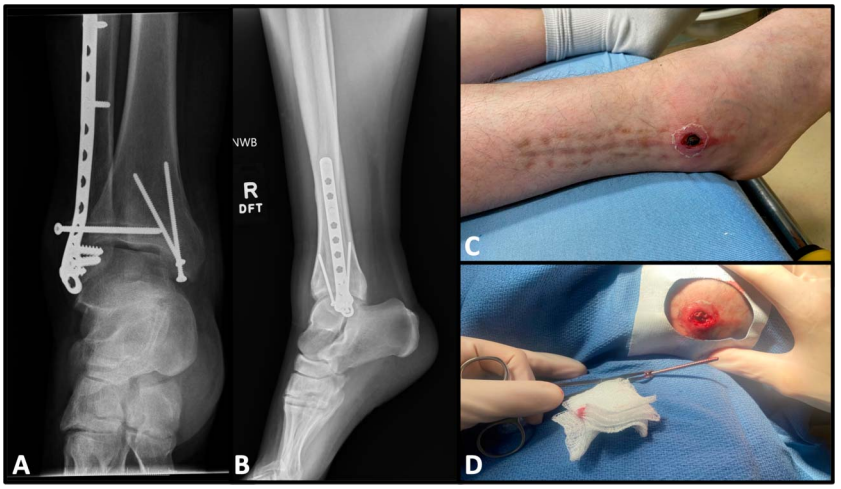


**FIGURE 3.** AP (A) and lateral (B) radiographs are shown of the healed ankle fracture, and it is clearly evident that the syndesmotic screw has backed out (A). A clinical photograph on presentation is shown, where the head of the syndesmotic screw is visible within the wound (C). The screw is shown after removal in the emergency department (D) before wound closure with absorbable sutures and placement of a soft dressing to minimize the need for an in-person immediate postoperative follow-up visit during the COVID pandemic. AP, Anteroposterior.

## Case 3

A 16-year-old male patient with bilateral femoral shaft fractures and an unstable thoracic spine fracture was transferred for higher level of care. The patient was neurologically intact, and the case was deemed urgent by the neurosurgical team. COVID status was unknown because testing results were not available before surgery. Owing to the patient's unknown COVID status, the orthopaedic surgeon optimized his PPE, wearing an N95, goggles, and a surgical hood when performing retrograde nailing of the femurs (Fig. 5). The

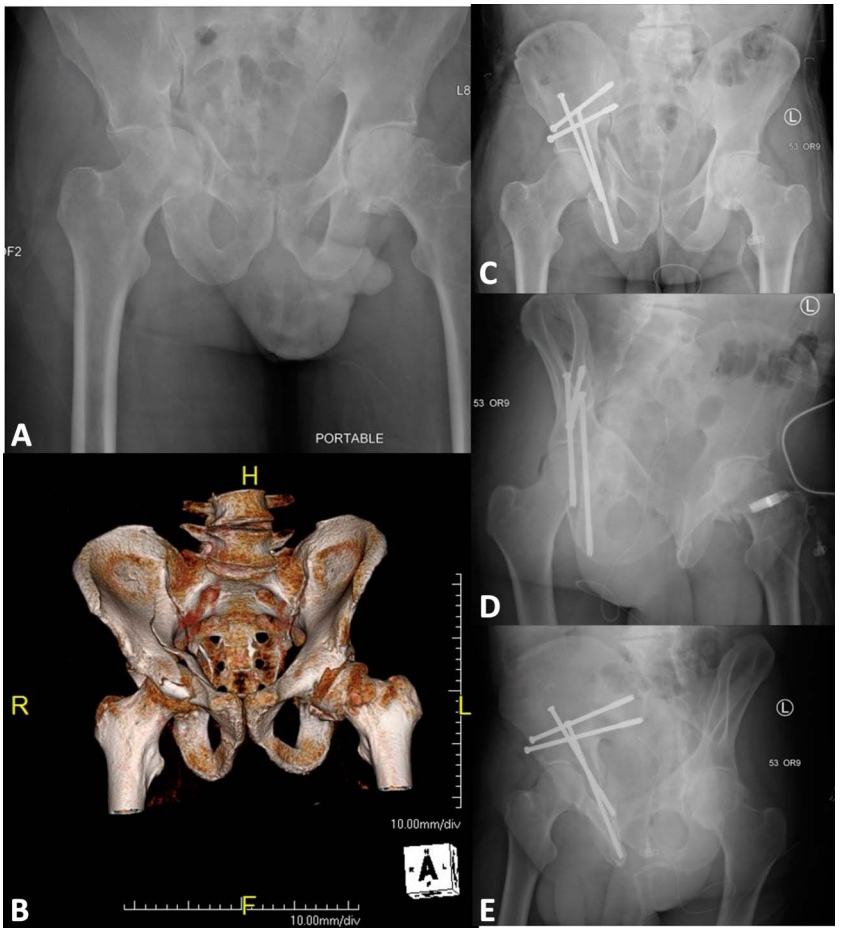


**FIGURE 4.** An AP and 3D reconstruction of the pelvis are shown (A, B), demonstrating the anterior column posterior hemitransverse. Postoperative AP and Judet views (C–E) demonstrate adequate reduction with limited internal fixation. AP, Anteroposterior.

**FIGURE 5.** PPE worn in a COVID unknown patient consisting of a surgical hood in conjunction N95 respirator in addition to standard operating room PPE.

patient then underwent prone positioning for a thoracic spinal fusion by the neurosurgery team during the same surgical setting.

## CONCLUSIONS

During a time when surgical volume has temporarily decreased substantially throughout the United States to optimize medical resource allocation and prevent the spread of SARS-CoV-2, orthopaedic trauma surgeons must remain vigilant and be prepared to optimally care for the injured trauma patient. During the COVID-19 pandemic, it is important to continually strive to provide better care for the patient while recognizing its impact on resource allocation and potential risk of spread of SARS-CoV-2 to the patient and/or health care workers. In addition, we must remember to use appropriate infection control practices as we can not only be infected with the SARS-CoV-2 virus, but we can also be an asymptomatic carrier and spread the virus to our patients, colleagues, families, and friends.

## REFERENCES


1. *WHO Director-General's Opening Remarks at the Media Briefing on COVID-19—11 March 2020.* Available at: https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19—11-march-2020. Accessed April 3, 2020.
2. *Coronavirus in the U.S.: Latest Map and Case Count. The New York Times*. 2020. Available at: https://www.nytimes.com/interactive/2020/us/coronavirus-us-cases.html. Accessed April 3, 2020.
3. Vannabouathong C, Devji T, Ekhtiari S, et al. The orthopaedic forum: novel coronavirus COVID-19: current evidence and evolving strategies. *J Bone Joint Surg Am.* 2020. In press.
4. van Doremalen N, Bushmaker T, Morris D, et al. Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. *N Engl J Med.* 2020 epub ahead of print.
5. Yeh HC, Jones RK, Muggenburg BA, et al. Characterization of aerosols produced during surgical procedures in hospitals. *Aerosol Sci Technol.* 1995;22:151–161.
6. Chang L, Yan Y, Wang L. Coronavirus disease 2019 : coronaviruses and blood safety. *Transfus Med Rev.* 2020 epub ahead of print.
7. Bai Y, Yao L, Tian F, et al. Presumed asymptomatic carrier transmission of COVID-19. *JAMA.* 2020 epud ahead of print.
8. Guo X, Wang J, Hu D, et al. The orthopaedic forum: survey of COVID-19 disease among orthopaedic surgeons in wuhan, people's repulic of China. *J Bone Joint Surg Am.* 2020 In press.
9. Schwartz A, Wilson J, Boden S, et al. Managing resident workforce and education during the COVID-19 pandemic. *J Bone Joint Surg Am.* 2020 In press.
10. Chavez S, Long B, Koyfman A, et al. Coronavirus disease (COVID-19): A primer for emergency physicians. *Am J Emerg Med.* 2020 epud ahead of print.
11. Coleman M, Seymour R, Bosse M. Utility of routine postoperative radiographs after fixation of lower extremity fractures. *J Am Acad Orthop Surg.* 2018;26:799–808.
12. Hollander J, Carr B. Virtually perfect? Telemedicine for COVID-19. *N Engl J Med.* 2020 epub ahead of print.
13. Sathiyakumar V, Apfeld JC, Obremskey WT, et al. Prospective randomized controlled trial using telemedicine for follow-ups in an orthopedic trauma population: a pilot study. *J Orthop Trauma.* 2015;29:e139–e145.
14. Smith AC, Thomas E, Snoswell CL, et al. Telehealth for global emergencies: implications for coronavirus disease 2019 (COVID-19). *J Telemed Telecare.* 2020. doi: 10.1177/1357633X20916567.
15. Robeznieks A. *Key Changes Made to Telehealth Guidelines to Boost COVID-19 Care*: American Medical Association; 2020. Available at: https://www.ama-assn.org/delivering-care/public-health/key-changes-made-telehealth-guidelines-boost-covid-19-care. Accessed April 3, 2020.
16. Mi B, Lang C, Xiong Y, et al. Characteristics and early prognosis of COVID-19 infection in fracture patients. *J Bone Joint Surg Am.* 2020 In press.
17. Spagnolo AM, Ottria G, Amicizia D, et al. Operating theatre quality and prevention of surgical site infections. *J Prev Med Hyg.* 2013;54:131–137.
18. Chow TT, Kwan A, Lin Z, et al. Conversion of operating theatre from positive to negative pressure environment. *J Hosp Infect.* 2006;64:371–378.
19. COVID-19 and Anesthesia FAQ. Anesthesia patient safety foundation. 2020. Available at: https://www.apsf.org/covid-19-and-anesthesia-faq/. Accessed April 7, 2020.
20. Air changes/hour (ACH) and time required for airborne-contaminant removal by efficiency. cdc.gov. Available at: https://www.cdc.gov/infectioncontrol/guidelines/environmental/appendix/air.html#tableb1. Accessed August 4, 2020.
21. Interim infection prevention and control recommendations for patients with suspected or confirmed coronavirus disease 2019 (COVID-19) in healthcare settings. cdc.gov. Available at: https://www.cdc.gov/coronavirus/2019-ncov/hcp/infection-control-recommendations.html. Accessed April 7, 2020.
22. UNMC Nebraska Medicine: Guidelines for patients with COVID-19 suspected or confirmed infection in the perioperative environment. 2020. Available at: https://www.nebraskamed.com/sites/default/files/documents/covid-19/guidelines-for-patients-with-covid-in-the-perioperative-environment.pdf. Accessed April 3, 2020.
23. Rodrigues-Pinto R, Sousa R, Oliveira A. The orthopaedic forum: preparing to perform trauma and orthopaedic surgery on patients with COVID-19. *J Bone Joint Surg Am Vol.* 2020 In press.

24. Radonovick L, Simberkoff M, Bessesen M, et al. N95 respirators vs medical masks for preventing influenza among health care personnel A randomized clinical trial. *JAMA.* 2019;322:824–833.
25. Macintyre CR, Chughtai AA, Rahman B, et al. The efficacy of medical masks and respirators against respiratory infection in healthcare workers. *Influ Other Respir Viruses.* 2017;11:511–517.
26. Oberg T, Brosseau LM. Surgical mask filter and fit performance. *Am J Infect Control.* 2008;36:276–282.
27. Derrick JL, Gomersall CD. Protecting healthcare staff from severe acute respiratory syndrome: filtration capacity of multiple surgical masks. *J Hosp Infect.* 2005;59:365–368.
28. Derrick JL, Li PTY, Tang SPY, et al. Protecting staff against airborne viral particles: in vivo efficiency of laser masks. *J Hosp Infect.* 2006;64:278–281.
29. Derrick JL, Gomersall CD. Surgical helmets and SARS infection. *Emerg Infect Dis.* 2004;10:277–279.
30. Hanselman AE, Montague MD, Murphy TR, et al. Contamination relative to the activation timing of filtered-exhaust helmets. *J Arthroplast.* 2017;31:776–780.
31. Hamzavi I, Lyons A, Kohli I, et al. Ultraviolet germicidal irradiation: possible method for respirator disinfection to facilitate reuse during COVID-19 pandemic. *J Am Acad Dermatol.* 2020 In press.
32. Nathan N. Waste not, want not: the Re-usability of N95 masks. *Anesth Analg.* 2020 In press.
33. Mills D, Harnish DA, Lawrence C, et al. Ultraviolet germicidal irradiation of influenza-contaminated N95 filtering facepiece respirators. *Am J Infect Control.* 2018;46:e49–e55.