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## Review article

# Orthopaedic operating room considerations in covid-19 pandemic: A systematic review



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## ABSTRACT

**Purpose:** Worldwide COVID 19 has affected the medical practices and Orthopaedics is not any different. Despite risk, the surgeons cannot deny the surgical procedure on patients with suspected or confirmed COVID 19 infection. The purpose of this manuscript is to review various operating room measures which are recommended and being followed to carry out orthopaedic surgeries in the current scenario of COVID 19 pandemic. The information would be useful for orthopaedic surgeons to carry out safe surgical practice for reducing the transmission of COVID 19 infection.

**Method:** ology: A systematic literature search was performed using search engines- PubMed, Google Scholar and Scopus from January to August 2020 for relevant research articles. The keywords utilized for systematic literature search were “COVID 19”, “Corona virus” and “Operating room”, “Orthopaedic procedure” in 4 combinations. Duplicates were excluded. Further sorting was done according to the pre-set inclusion and exclusion criteria. Original articles pertaining to orthopaedic surgery and operating room in COVID 19 and available in English language were included. Editorials, case reports, other speciality articles were excluded.

**Results:** 16 articles were finally included in review after screening for titles, abstracts and full texts. The information obtained is presented as a narrative review.

**Conclusion:** Various important recommendations include use of negative pressure OR, HEPA filters, dedicated separate OR for COVID positive and suspected patients with well defined separate corridors for transport, avoid AGP wherever possible, minimize the number of assistants and staff and follow strict sanitation protocols after each surgery. A well planned systematic approach is warranted to mitigate the risk of transmission of COVID 19 while carrying out orthopaedic surgeries.

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## 1. Introduction

Covid-19 or SARS-CoV-2 is an infectious disease that has spread rapidly over the entire world.<sup>1,2</sup> The outbreak was started from Wuhan province, China in December 2019, and World Health Organisation (WHO) has declared it as pandemic in March 2020.<sup>3</sup>

Covid-19 has heavily affected the healthcare system. Elective orthopaedic procedures were postponed in order to reduce the

burden on health system. As the number of cases are now decreasing, the elective surgeries may have to be resumed. While operating on covid suspected or positive patient, there is high probability of getting infection to surgeons and other staff in operating room, it must be ensured that all surgeries be done safely, without exposing patients or health-care providers to infection.<sup>4</sup>

The purpose of this systematic review is to look at the current literature on methods required for conducting safe orthopaedic surgeries during COVID-19 pandemic and formulate practical recommendations on desired changes in the operating room while performing orthopaedic procedure on a covid-19 suspected or positive patient.

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## 2. Material and methods

A systematic literature search was performed using PubMed, Google scholar and Scopus. The electronic database was screened of all the articles published between January 2020 to August 2020. The search was conducted using following keywords- “COVID 19”, “coronavirus”, “orthopaedic procedures” and “operating room” in different combinations. The selected articles were sorted in an excel sheet and the duplicate articles were removed. Original articles pertaining to orthopaedic surgeries in COVID patients available in English language were included in the review. Case reports and editorials were excluded from the study. The selected articles were initial screened through titles and thereafter by abstract reading and final list were prepared after full text reading.

## 3. Results

After removing the duplicate articles, we obtained 630 articles from our electronic search using the combinations of keywords. These 630 articles were screened using our exclusion criterion and 229 articles were obtained.

A second screening of these 229 articles was conducted by going through the titles. One hundred seven articles were excluded and 122 articles on the basis of abstract reading, 106 articles were removed. The final list of 16 articles was made (Fig. 1). These 16 articles were randomly distributed amongst 4 authors for full text reading. These 16 articles are listed in Table 1.

As the data was heterogenous, it was not possible to perform a systematic review and the obtained information is provided as a narrative review.

## 4. Discussion

The data extracted from the included articles is discussed under the following headings for simplification.

### 4.1. Screening

It has become a practice to screen each patient requiring surgery for COVID 19. Screening includes history of contact, symptoms of COVID and tests including rapid antigen test, RT-PCR as well as CT chest.<sup>9</sup> Although there is risk of infection, it is impossible for surgeons to avoid operating in all suspected or COVID positive patients. Surgeons require to decide whether to operate or not on the basis of patient’s clinical status, indication of surgery (urgent/emergency/non-urgent) and available resources.<sup>9</sup>

### 4.2. Operating room (OR) ventilation

Usually, the direction of airflow in the operating room complex is from the OR towards the surrounding area (positive pressure).<sup>24</sup> A positive pressure OR is one in which the air pressure inside the OR exceeds that of the surrounding adjacent areas and hence restricts contamination of surgical field by contaminants from surrounding environment. A negative pressure OR on the other hand is one which maintains lesser air pressure inside than the surrounding environment and hence restricts any dissemination from within the OR. Positive pressure environment is utilized to reduce the risk of surgical site infection by contamination; however, it will not restrict the dissemination of infectious particles from inside the OR to outside environment. Hence, a negative pressure OR with separate ventilation system and HEPA filter is desirable for performing surgery on COVID 19 positive/suspected patient to mitigate the risk of cross transmission amongst patients and staffs. Twelve

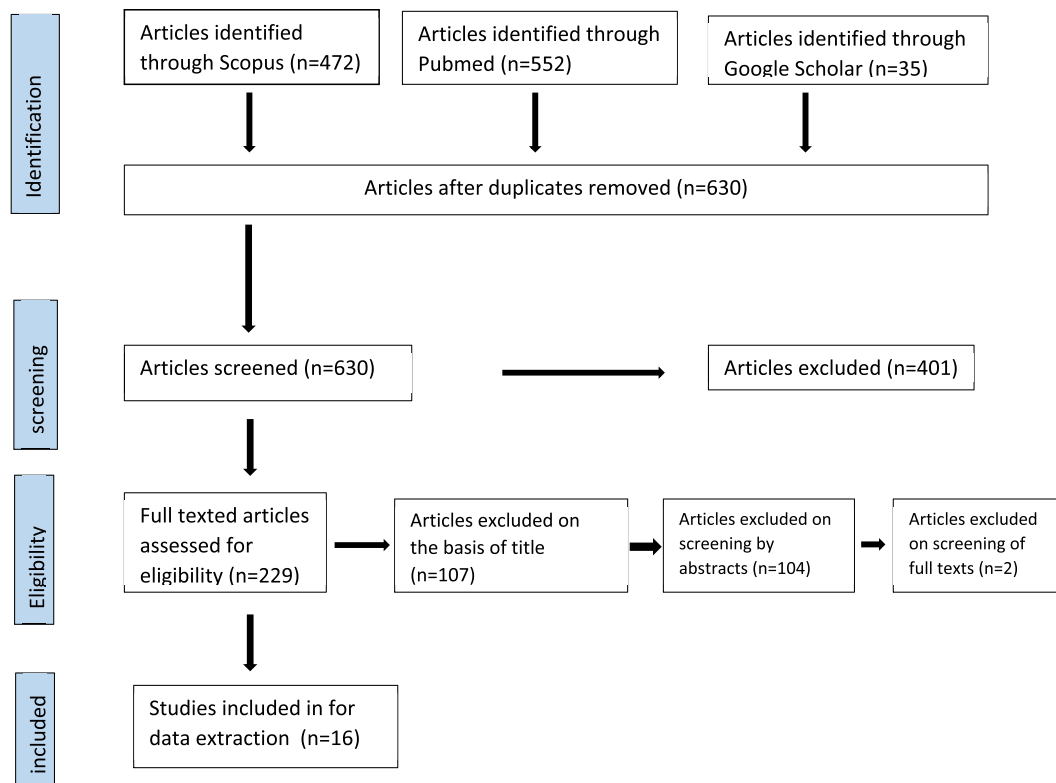


Fig. 1. Prisma Flow diagram showing the flow of information in the systematic review.

**Table 1**  
Summary of total articles reviewed.

Sr. No.	Author	Article	OR environment				AC	Separate OR for COVID
			Negative pressure OR	HEPA Filter	Laminar airflow			
1	Abdelnasser MK et al. <sup>5</sup>	COVID-19. An update for orthopaedic surgeons	Yes, with separate ventilation system	Recommends to add HEPA filters to positive pressure room if negative pressure not available,	N.A	No	Yes	
2	Ambrosio L et al. <sup>6</sup>	The role of the orthopaedic surgeon in the COVID-19 era: cautions and perspectives	Yes; If not available, turn off positive pressure and use HEPA filter	HEPA filter with frequent air exchange to be used In case of positive pressure OR	N.A	N.A	Yes	
3	Barry TWL et al. <sup>7</sup>	In the Extraordinary Times of Coronavirus Disease 2019: Clinical Strategies for Performing Spinal Surgery	Yes; 6–12 cycles of air change per hour	N.A	N.A	N.A	Yes, with specific access corridors	
4	Casiraghi A et al. <sup>8</sup>	Operational strategies of a trauma hub in early coronavirus disease 2019 pandemic	N.A	N.A	N.A	N.A	Yes	
5	de Caro F et al. <sup>9</sup>	Returning to orthopaedic business as usual after COVID-19: strategies and options	Yes	N.A	N.A	N.A	N.A	
6	Ding BTK et al. <sup>10</sup>	Operating in a Pandemic: Lessons and Strategies from an Orthopaedic Unit at the Epicenter of COVID-19 in Singapore	Yes	Minimum 15 air changes per hour through HEPA filter	NA	NA	NA	
7	Geevarughese NM and Ul-Haq R <sup>11</sup>	Aerosol generating procedures in orthopaedics and recommended protective gear	Negative pressure OR with minimum 12 air changes per hour for AGPs	Exhaust air is filtered through HEPA	NA	NA	NA	
8	Hirschmann MT et al. <sup>12</sup>	COVID-19 coronavirus: recommended personal protective equipment for the orthopaedic and trauma surgeon	N.A	N.A	N.A	N.A	N.A	
9	Kenanidis E et al. <sup>13</sup>	Organizing an Orthopaedic Department During COVID-19 Pandemic to Mitigate In-Hospital Transmission: Experience From Greece	Negative pressure OR	Yes	N.A	N.A	Yes	
10	Mi B et al. <sup>14</sup>	COVID-19 Orthopaedic Safe Care Toolset: Guidelines for the Diagnosis and Management of Patients with Fracture and COVID-19	Negative pressure OR/Independent airflow system	N.A	Laminar airflow to be switched off immediately after surgery	N.A	N.A	
11	Parvizi J et al. <sup>15</sup>	Resuming Elective Orthopaedic Surgery During the COVID-19 Pandemic: Guidelines Developed by the International Consensus Group (ICM)	Ventilation system with minimum 20 air changes per hour. Normal positive pressure OR for elective procedures. No need of negative pressure; Though in room air filters, negative pressure ante chamber can be used.	Yes	N.A	N.A	N.A	
12	Sadigale O et al. <sup>16</sup>	Resuming arthroplasty: A well aligned and a balanced approach in the COVID-19 era	Negative pressure OR with 20 air changes per hour is recommended; Avoid positive pressure OR	N.A	Yes	N.A	N.A	
13	Service BC et al. <sup>17</sup>	Medically Necessary Orthopaedic Surgery During the COVID-19 Pandemic: Safe Surgical Practices and a Classification to Guide Treatment	Yes	N.A	N.A	N.A	N.A	
14	Verma V et al. <sup>18</sup>	Adapting Policy Guidelines for Spine Surgeries During COVID-19 Pandemic in View of Evolving Evidences: An Early Experience From a Tertiary Care Teaching Hospital Recommendations of protective measures for orthopaedic surgeons during COVID-19 pandemic	N.A	Individual OR having separate ventilation system and HEPA filters	N.A	N.A	N.A	
15	Wang Y et al. <sup>19</sup>	Recommendations of protective measures for orthopaedic surgeons during COVID-19 pandemic	Negative pressure OR (- 5 Pa)	Hepa filter must be used	N.A	N.A	Yes	
16	Stinner DJ et al. <sup>20</sup>	The Orthopaedic Trauma Service and COVID-19: Practice Considerations to Optimize Outcomes and Limit Exposure	Negative pressure OR	N.A	N.A	N.A	Yes	

out of 16 articles recommend use of a negative pressure OR, whereas one article<sup>15</sup> mentions that there is no need of negative pressure OR and a positive pressure OR with minimum 20 air changes per hour and in-room air filter and negative pressure antechamber can be used for elective surgeries. Since positive-pressure ORs are usually utilized to reduce the risk of surgical contamination,<sup>6,24</sup> there conversion to negative pressure OR in the wake of this COVID pandemic should be planned carefully and will

require OR maintenance. Some hospitals have ORs with reversible ventilation mode, while others also have positive-pressure ORs with a negative pressure anteroom.<sup>20</sup> If it is not feasible to have a negative pressure OR, positive pressure should be turned off and a HEPA filter with frequent air changes should be used.<sup>23</sup> One article mentions about air conditioner in OR and recommend that AC should be switched off during the surgery.<sup>5</sup> One article on resuming arthroplasty surgeries recommends use of laminar air flow in a

negative pressure OR.<sup>16</sup> Only one article mentions the value of recommended pressure in negative pressure OR to be  $-5 \text{ Pa}$ .<sup>19</sup> Recommended air changes per hour in OR ventilation is variable in different articles. Barry TWL et al.<sup>7</sup> recommend 6–12 air change per hour for aerosol generating procedures; Geevarughese NM and Ul-Haq R<sup>11</sup> recommend minimum 12 air changes per hour, whereas Sadigale O et al.<sup>16</sup> recommend minimum 20 air changes per hour in arthroplasty surgeries.

#### 4.3. HEPA filter

HEPA filters are high efficiency air filtration systems that restrict the passing particles by diffusion, interception, and inertial impaction.<sup>21</sup> The filtration effectiveness of HEPA filters is around 99.97% of  $0.3 \mu\text{m}$  particles.<sup>22</sup> The size of aerosol droplets is  $1\text{--}5 \mu\text{m}$ .<sup>21</sup> Orthopaedic surgeries often involve multiple aerosol generating procedures and HEPA filters with frequent air changes per hour should be helpful by filtering out the aerosol particles from the air. Eight articles recommend use of HEPA filters to reduce the risk of COVID 19 transmission. Ding BTK et al.<sup>10</sup> recommends HEPA filter with minimum 15 air changes per hour. Abdelnasser MK et al.<sup>5</sup> and Ambrosio et al.<sup>6</sup> also recommend to add HEPA filters to positive pressure room if negative pressure is not available.

#### 4.4. Separate OR for COVID patients

Seven articles<sup>5–8,13,19,20</sup> mention and recommend about having separate designated OR for COVID positive or suspected patients. Hospitals should also designate separate specific corridors/walkways for transfer of COVID positive or suspected patients to OR.<sup>10</sup> The pathways to OR should be well defined and proper labelling of corridors is necessary to avoid any confusion. A unidirectional flow of OR staff should be maintained with minimum door opening.

#### 4.5. Surgical team and OR staff management

Twelve out of 16 articles recommend that minimum number of staff members should be kept inside the OR for any surgical procedure.<sup>5–7,10,11,13–16,18–20,25</sup> Less number of staff will facilitate the implementation of social distancing and also reduce the PPE demand.<sup>18</sup> It is advised that experienced surgeon with highest skill should perform the procedure to avoid prolonged surgical duration and hence exposure time.<sup>5,7,13,14,16,18</sup> Sadigale O et al.<sup>16</sup> recommend maximum of 8 persons in surgical team with carefully selected personnel based on their experience and familiarity to the procedure. Trained staff and personnel for specific surgeries should be incorporated in the team. Unnecessary movement in the OR complex should be strictly discouraged.<sup>6</sup> Sales representatives should also not be allowed in OR until strictly needed.<sup>5,6,14,19,20</sup> Verma V et al.<sup>18</sup> utilized a surgical team including chief surgeon, senior resident, junior resident, and scrub nurse. Barry TWL et al.<sup>7</sup> utilized minimal personnel in spine surgeries which consisted of the spine surgeon, a resident, one scrub nurse, and one circulating nurse. It is advised to do daily screening and close monitoring of peri-operative teams with temperature assessment to identify early disease.<sup>17</sup> Service BC et al.<sup>17</sup> recommend using surgical teams separated physically performing work on alternate weeks to avoid exposure of the entire staff. If patient is to be operated under GA and intubated, surgical team should not be present inside the OR during intubation and around 20 min after that depending on the air change frequency as intubation is an aerosol generating procedure.<sup>7,14,16,18</sup>

#### 4.6. Use of personal protective equipment (PPE)

Each article recommends proper use of PPE in operating rooms. The PPE should include surgical gowns, surgical hood (to cover head and neck), facemasks (N95/FFP2) with a face shield/goggles or Powered Air-Purifying Respirator (PAPR) and fluid resistant shoes or boots.<sup>5,6,26</sup> Association of Advancement of Medical Instrumentation (AAMI) grading classifies surgical gowns on the basis of liquid barrier capacity. Personnel in operating room should use AAMI level III surgical gown. Proper hand hygiene and donning and doffing technique are necessary. Personnel should be vigilant to avoid self-contamination during PPE doffing. N95 or FFP 2 masks have 95% filtration efficiency for particles of size  $0.3 \mu\text{m}$ . N95/FFP2 use is essential when operating a suspected or positive patient as routine surgical masks do not provide good protection against aerosols in high risk aerosol generating procedures.<sup>12</sup> A simple surgical mask can however be worn over N-95 to prevent gross contamination. N95 respirator must be checked for not being soiled or damaged before reuse. Full face shield is preferred to protective eye goggles. Multiple surgical masks should also not be used as alternative to N95/FFP2 as it also fails to filter virus loaded particles.<sup>8</sup> In addition to the type of masks used, the fitting and sizing of the mask is of utmost importance. Only a perfect-sized and well-fitted mask leads to efficient sealing of the respiratory tract. PAPR respirator filters out contaminants from air using a battery powered unit. Ding BTK et al. advise to use PAPR for prolonged surgeries ( $>4 \text{ h}$ ) in COVID 19 patients.<sup>6</sup> However, PAPR's higher cost, reduced visual field, regular requirement of maintenance, difficulties in hearing etc are its disadvantage.

#### 4.7. Aerosol generating procedures (AGPs)

Orthopaedic surgeries involve multiple procedures which generate aerosol. These include use of power drill, oscillating saw, harmonic scalpel, pulse lavage, burr, cautery, reaming etc which are very often utilized. Nogler et al. demonstrated that aerosols spread in up to  $6\text{--}8 \text{ m}$  are generated by high-speed cutters during revision hip arthroplasty.<sup>27</sup> Electro-cautery should be used minimally and in minimum setting possible along with a smoke evacuator.<sup>5,6,13,15,17–19,26</sup> Power devices like drills, saws, reamers and burr should also be used minimally and the power settings should be as low as possible.<sup>5–7,9,11,12,15–19</sup> Considering using a Gigli saw, sharp osteotomes, and manual reaming whenever possible.<sup>15,18</sup> Use of negative pressure OR, HEPA filter and proper PPE is imperative to attenuate cross-infection.<sup>11</sup>

### 5. Conclusion

Recommendations include use of negative pressure OR, HEPA filters, dedicated separate OR for COVID positive and suspected patients with well defined separate corridors for transport, avoid aerosol generating procedures wherever possible, minimize the number of assistants and staff and follow strict sanitation protocols after each surgery.

#### Declaration of competing interest

None.

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