



Effect of COVID-19 on surgical management of open fractures and infection rates: A tertiary care experience in Indian set-up



Ravi Gupta ^a, Akash Singhal ^{b, *}, Anil Kapoor ^c, Mehar Dhillon ^c, Gladson David Masih ^c

^a Sports Injury Center, Government Medical College Hospital, Chandigarh, India

^b Government Medical College and Hospital, Chandigarh, India

^c Department Of Orthopaedics, Government Medical College and Hospital, Chandigarh, India

ARTICLE INFO

Article history:

Received 13 September 2020

Received in revised form

19 October 2020

Accepted 23 October 2020

Available online 26 October 2020

Keywords:

COVID-19

Open fractures

Infection rates

Referral cases

Readmission rates

External fixator

ABSTRACT

Background: Open fractures form one of the most common musculoskeletal injuries and are often complicated by infection. In this unprecedented situation, the additional infection rates, further add to the burden of the already compromised healthcare setup. The present study is done to see the effect of COVID-19 on management of open fractures.

Methods: A retrospective evaluation of patients with open fractures from March 25th 2020 to July 21st 2020 (group 1) and March 25th 2019 to July 21st 2019 (group 2) was performed. These patients were assessed for demographic details, diagnosis, type of surgery, delay from injury to admission, delay from admission to surgery, postoperative hospital stay, acute infection rates, readmission rates and associated injuries.

Results: A total of 52 patients with 59 open fractures in 2020 and 89 patients with 101 open fractures in 2019 met the inclusion criteria. The mean age was 34.76 years and 32.74 years in 2020 and 2019 respectively. Road side accidents were predominant in both the groups, comprising of 38 (73.07%) and 67 (75.28%) respectively(n.s.); adult patients were 42 (80.76%) and 79 (88.76%) respectively(n.s.); paediatric patients were 10 (19.23%) and 10 (11.23%) respectively(n.s.); tibia was the most common bone involved, comprising of 14 (23.72%) and 27 (26.73%) open fractures respectively(n.s.); external fixator was the most commonly used implant during COVID-19 time with 42 (71.18%) and 51 (50.49%) respectively(p = 0.005); the infection rate was 25.42% and 20.79% respectively(n.s.); the time for administration of first intravenous antibiotic dose was on 6.75 h and 4.04 h respectively(p < 0.0001); average time between the admission and surgical debridement was 24.04 h and 19.32 h respectively(n.s.); referral cases were 33 (63.46%) and 44 (49.43%) respectively(n.s.); re-admission rates were 7/52 (13.46%) and 10/89(11.23%) respectively(n.s.).

Conclusion: Despite the decrease in total trauma cases, a delay in presentation to the emergency room/ administration of first dose of antibiotic and increase in temporary fixation in form of external fixator was observed. Further, an increase in infection rates, referral cases and readmission rates were observed, though not statistically significant.

© 2020 Delhi Orthopedic Association. All rights reserved.

1. Introduction

Contemporaneous management of open fractures during COVID-19 pandemic has taken a hit and especially in densely populated countries like India, where cases are increasing at an

alarming rate with each passing day.¹ In these testing times, orthopaedic surgeons all over the world are facing a complex dilemma regarding the priority of treatment, complications associated with injuries, safety of staff, patient, the operating surgeon himself and how to triage the patients on the basis of available resources.² Efforts are being made to tackle this sudden unprecedented problem by moving towards old tried and tested methods of conservative management and utilizing the available resources in the best possible way.³ Furthermore, use of evidence based approach on case to case basis will help in avoiding foreseeable

* Corresponding author.

E-mail addresses: ravigupta2000@yahoo.com (R. Gupta), akash15636@gmail.com (A. Singhal), anil88gmch@gmail.com (A. Kapoor), mehardhillon16@gmail.com (M. Dhillon), gladsondavid32@gmail.com (G.D. Masih).

complications, which can prevent further worsening of this COVID-19 scenario.⁴

Open fractures, unreduced dislocations, crush injuries, traumatic amputation, compartment syndrome, multiple long bone fractures and septic arthritis, all form the emergent nature of orthopaedic injuries and need to be dealt on an urgent basis.⁵ Out of these, open fractures form one of the most common musculo-skeletal injuries and are often complicated by infection, leading to prolonged morbidity to the patient.^{6,7} Many of these present with treatment challenges according to the available resources and vary on case to case basis.⁸ Although, evidence based approach can help in reducing these management issues on a case to case basis, the universal treatment protocols/guidelines for management of many of these open fractures, still remains a controversial issue.⁴

Untimely management of open fractures are associated with impaired bone healing, wound healing problems and high infection rates, leading to long term disabilities causing prolonged distress to the patient.^{6,7} Further, with a high number of already present neglected trauma cases due to delayed presentation, misdiagnosis, continuation of a failed conservative treatment and lack of resources at all the health centres all over India, poses with a never ending influx of problems, overburdening the already compromised hospital resources in this COVID-19 scenario.¹ Also, presence of non-specialist doctors, quacks, osteopaths, treatment under suboptimal theatre conditions, closure of outpatient departments, conversion of various trauma centres to dedicated COVID centres, positioning of anaesthetist in various ICU wards, closure of elective operation theatre and delegation of the available manpower to COVID related duties adds burden on an already struggling healthcare system.^{1,9} Internationally various healthcare systems even from the wealthiest of the countries are in a fragile state, reflecting the need of revisiting already made treatment protocols to triage the orthopaedic trauma better.¹⁰

With the objective of analysing and understanding the present scenario, comprehending the current acute management of open fractures, this text centres on focussing on large number of those controversial discussions. With the aim of summarizing the present understanding of best evidence for the acute treatment of open fractures, this supplement focuses on addressing many of those critical controversies. This paper will add to the debate and hopefully provide a framework for decision making in open fracture care during this difficult time.

2. Materials and methods

This is a retrospective cohort study carried out in a tertiary care setup. The information got is the aftereffect of the impact of the pandemic on the population and of the national and state government's lockdown of the apparent multitude of exercises including medical non-necessary exercises that occurred at various occasions through the nation as indicated by the development of the Covid-19 flare-up. A thorough evaluation of data pertaining to the open fractures was retrieved from medical records department, emergency room record books and operation theatre record books from March 25th 2020 to July 21st 2020. The data collected was compared with the data of the previous year (2019) for an equivalent time duration, record of which was maintained in the medical records department, emergency operation theatre record books and operation theatre record books. Those patients, who died as a result of trauma or could not be operated/refused to get operated upon, were excluded from the study. The data included demographic details, diagnosis, type of surgery, delay in injury and admission, delay in admission and surgery, postoperative hospital stay, acute infection rates (1–30 days) needing repeat debridement, readmission rates and associated injuries including head injuries

and blunt trauma chest/blunt trauma abdomen injuries. The data obtained from patient's records was classified according to severity of the fracture using classification system of Gustilo and Anderson.¹¹ The surgical activity recorded was divided into 3 types including upper extremity fractures, lower extremity fractures and pelvis and acetabulum trauma.

All the patients presenting to the emergency were managed in our hospital by an integrated surgery team, including both orthopaedic and other specialities, with a prescribed care pathway for diagnosis and treatment according to the ATLS guidelines.¹² The patients were screened for temperature charting, flu like symptoms and travel history. All the patients were screened for COVID-19 using Reverse Transcriptase- Polymerase Chain Reaction (RT-PCR) method. Patients requiring emergency limb or lifesaving surgeries were operated by a dedicated team of surgeons in dedicated Covid operation theatres (OT) without waiting for the (RT-PCR) Covid report.

2.1. On presentation to the emergency room

Open fractures were treated according to the given protocol as under:

1. The injuries were clinically assessed, washed to remove superficial debris and covered with sterile dressing and a picture was taken to forestall rehashed exposures.
2. Intravenous antibiotic therapy was given on presentation to the emergency room and during admission as per the EAST practice management guidelines¹³
3. Anti-tetanus prophylaxis
4. Temporary stabilization of the fracture was done with a cardboard splint and patient was sent for x-rays

Clinical examination findings including discharge, redness, warmth, and swelling were assessed along with the blood investigation reports of serial Erythrocyte Sedimentation Rate (ESR)/C-reactive protein (CRP) and culture sensitivity findings to assess for the infection during first 30 days post-operatively.

2.2. Statistical analysis

Quantitative information was introduced as mean \pm SD or middle and interquartile extent, as suitable. Kolmogorov Smirnov tests were used to check normality of the data. Mann-Whitney test was used for skewed data. Independent *t*-test used for ordinarily distributed data. Proportions were equated with the help of Chi-square or Fisher's exact test where applicable. At a significance level of $\alpha = 0.05$, all the tests were interpreted. The data was analysed using IBM SPSS STATISTICS (version 22.0).

3. Results

A total of 52 patients with 59 open fractures in 2020 and a total of 89 patients with 101 open fractures in 2019 were admitted for the given time period. The mean age was 34.76 years and 32.74 years in 2020 and 2019 respectively (Table 1). Of these, there were a total of 45 males and 7 females in 2020 and 78 males and 11 females in 2019 for the same time period (Table 1). Road Side Accidents comprised of most injuries, with 38 (73.07%) patients in 2020 and 67 (75.28%) patients in 2019 (Table 2). Adult patients in 2020 and 2019 were 42 (80.76%) and 79 (88.76%) respectively while paediatric patients were 10 (19.23%) and 10 (11.23%) respectively (Table 2). The distribution of the fracture type of 2020 and 2019 is summarised in Table 2, with the tibia being the most common bone involved, comprising of 14 (23.72%) and 27 (26.73%) open fractures

Table 1
Demographic details of patients.

Category	2020 patients (n = 52)	2019 patients (n = 89)	P value
Age (years)	34.76 (3–81)	32.74 (3–87)	0.57
Gender (males: females)	45:7	78:11	0.99
Referral cases (n)	33 (63.46%)	44 (49.43%)	0.11
Direct Admissions (n)	19 (36.53%)	45 (50.56%)	0.20
Delay from injury to presentation in emergency/administration of antibiotic (Hours)	6.75 (1–15)	4.04 (1–14)	<0.0001
Delay from admission to surgery (Hours)	24.04 (8–96)	19.32 (6–72)	0.15
Type of surgery			
External fixator application	42 (71.18%)	51 (50.49%)	0.005
Plating	6 (10.16%)	14 (13.86%)	0.61
Nailing	5 (8.47%)	24 (23.76%)	0.01
K wiring/screw fixation/Tension band	5 (8.47%)	10 (9.90%)	0.98
Amputation	1 (1.69%)	2 (1.98%)	0.89
Post-operative hospital stay (Days)	3.12 (3–21)	3.34 (3–27)	0.81
Re-admission rate (within 30 days)	7/52 (13.46%)	10/89(11.23%)	0.79

Table 2
Distribution of open according to trauma mechanism.

Trauma Mechanism	2020 data (n = 52)	2019 data (n = 89)	P value
Category			
Road Side accidents	38 (73.07%)	67 (75.28%)	0.84
Fall from height	3 (5.76%)	6 (6.74%)	0.81
Firearm Injuries	2 (3.84%)	3 (3.37%)	0.88
Sports Injuries	2 (3.84%)	5 (5.61%)	0.64
Assault	5 (9.61%)	7 (7.86%)	0.76
Crush Injuries/Railway Track Injuries	2 (3.84%)	1 (1.12%)	0.55
Data for Surgical Interventions performed(Conservative excluded)			
Upper limb fracture	17 (28.81%)	24 (23.76%)	0.57
Humeral fractures	1	2	0.89
Elbow fractures	3	6	0.82
Forearm fractures	5	6	0.54
Wrist fractures	1	1	0.69
Hand fractures	7	9	0.59
Lower limb fractures	33 (55.93%)	70 (69.30%)	0.08
Femur fractures	4	11	0.38
Knee fractures	3	8	0.74
Tibia fractures	14 (23.72%)	27 (26.73%)	0.71
Ankle fractures	4	7	0.97
Foot fractures	8	17	0.65
Pelvis and Acetabulum fractures	1 (1.69%)	2 (1.98%)	0.89
Adult Patients	42 (80.76%)	79 (88.76%)	
Paediatric Patients	10 (19.23%)	10 (11.23%)	
Distribution according to Gustilo Anderson Classification			
Grade 1	12 (20.33%)	11 (10.83%)	0.10
Grade 2	16 (27.11%)	27 (26.73%)	0.95
Grade 3	31 (52.54%)	63 (62.37%)	0.24
Grade 3A	21	43	0.40
Grade 3B	9	17	0.79
Grade 3C	1	3	0.61
Comparison of infection rate in open fractures according to the time duration in 2020 and 2019, and needed re-debridement			
	2020 patients (n)	2019 patients (n)	P value
Total Infection rate	15 (25.42%)	21 (20.79%)	0.55

respectively (Table 2). Implants used to stabilise the open fractures is summarised in Table 1, with the external fixator being the most commonly used implant with 42 (71.18%) and 51 (50.49%) in 2020 and 2019 respectively (Table 1). Distribution of fractures according to the Gustilo and Anderson classification is summarised in Table 2, with the open grade 3 type comprising of the majority of the open fractures both in 2020 and 2019 for same time period. Rate of infections in patients operated for open fractures according to Gustilo and Anderson classification in 2020 and 2019, and the need for re-debridement was 25.42% and 20.79% respectively, with the open grade 3 type comprising of the majority of the infection in both the years (Table 3). The delay from injury to presentation to emergency and administration of antibiotic was on average 6.75 h and 4.04 h for patients in 2020 and 2019 respectively (Table 1). The average

time between the admission and surgical debridement in hours was 24.04 h and 19.32 h for 2020 and 2019 respectively (Table 1). Other demographic details including referral cases, direct admissions, readmission rates and post-operative hospital stay is summarised in Table 1. There were a total of 7 (11.86%) and 17 (16.83%) patients respectively with associated head injuries and a total of 9 (15.25%) and 15 (14.85%) patients respectively with associated blunt trauma chest/blunt trauma abdomen for the same time period in 2020 and 2019.

4. Discussion

The most important finding of the present study is that despite the reduction in the number of open fractures as per the hospital

Table 3

Rate of infections in patients operated for open fractures according to the time duration and needed re-debridement.

Rate of infections in patients operated for open fractures (2020) and needed re-debridement				
Category	Gustilo Anderson type 1 (n=12)	Gustilo Anderson type 2 (n=16)	Gustilo Anderson type 3 (n=31)	Total (n)
0 to 3 days	1	2	3	6
4 to 7 days	1	1	5	7
8 to 21 days	-	-	1	1
22 to 30 days	-	-	1	1
Total Infections	2 (3.38%)	3 (5.08%)	10 (16.94%)	15 (25.42%)
Rate of infections in patients operated for open fractures (2019) and needed re-debridement				
	Gustilo Anderson type 1 (n=11)	Gustilo Anderson type 2 (n=27)	Gustilo Anderson type 3 (n=63)	Total (n)
0 to 3 days	1	3	7	11
4 to 7 days	1	2	4	7
8 to 21 days	-	-	2	2
22 to 30 days	-	-	1	1
Total Infections	2 (1.98%)	5 (4.95%)	14 (13.86%)	21 (20.79%)

registry records during the lockdown period, there has been a delay in presentation to the emergency room/administration of antibiotic ($p < 0.0001$). Further, an increase in time duration from admission to surgery, total infection rate, referral cases and 30 days readmission rate was observed, though not statistically significant. In addition, there was an increase in external fixator application rate as temporary mode of management for open fractures for the same time period ($p = 0.005$) compared with the previous year, when internal fixation (nailing) was done more, though the distribution of open fractures according to the Gustilo Anderson classification is quite the same for the time period as previous year.

Lockdown and isolation measures related with the deduction of business activities and commercial foundations led to the progressive abatement of trauma cases particularly open fracture cases, related to work and sports activities. Moreover those individuals were at home and in home isolation, the quantity of domestic violence at home and road side accidents decreased progressively over the period of few weeks. Further, because of the public campaign begun by the media and the ministry of health to decrease the admittance to trauma centre, except if carefully vital, related with the fear of everyone getting contaminated by COVID-19, there has been a drastic decrease in acute injury cases presentation to the trauma centre. Similar reports by different authors from other countries state the same scenario.^{14,15} Further, with less availability of public transportation, the fear of acquiring the disease among the public and lockdown prevailing in the different parts of the country, there was a drastic drop in citizens choosing public transport as means of communication, which lead to a decrease in trauma cases, which is expected to continue for some weeks in the near future. However, these lockdown restrictions, unavailability of public transportation and strictness of maintaining social distance, forced the daily wage workers to walk by foot or to take other means of transportation, leading to an increase in severity of injury and thus more high energy trauma. In addition to the lack of transportation, the imposition of intra-state and inter-state restrictions slowed down the pace of the traffic and thus a delay in the presentation. Also, the conversion of more and more local health care setups into COVID-19 designated hospitals, patients are being referred to the nearest tertiary care set-up leading to a delay in the presentation to the emergency room, as observed in the present study with increase in the referrals for the same time period compared to the previous year. Further, keeping in mind the economic implications in a developing country like India has led to the delay in the treatment, as most of the patients are daily wage earners, who are not able to afford the treatment due to the prevailing lockdown conditions.

There is a considerable variation in reported infection rates in

literature following open fractures. Where a study by Muller et al. reports infection rates in up to 20.50% of patients with open fractures, other author's report an overall infection rate of 13.24%.^{15–19} In the present study, acute infection rate of 25.62% and 20.79% in 2020 and 2019 respectively, was observed. The increase in the acute infection rates for the period in 2020 can be attributed to the fact that there was a delay in presentation/referral to the tertiary care setup and thus a delay in administration to the dose of the antibiotics. Further, there was a delay in admission to surgical intervention done. Fernandes et al. in their study found no statistical difference in the infection rates when debridement was done before 6 h and after 6 h, though they report increased infection rates in the patients operated after 6 h.¹⁹ Further, they mentioned that a waiting time somewhere in the range of 6 h–24 h for the careful management of open fractures can allow better preoperative, better acknowledgment of the seriousness of related wounds, and thus satisfactory clinical stabilization.¹⁹ No scientific conclusive data exists in the current literature reporting that the delay in surgical debridement leads to an increase in the incidence of infection.^{19–23} Further, Ketonis et al. and Schenker et al. in their reviews have mentioned that there exists a correlation between early administrations of antibiotics with decreased infection rates, which corresponds with the results of the present study with the increased infection rates in 2020 for the same time duration when compared with the infection rates of the previous year, as besides the delay in the surgical intervention from the time of admission, there was a delay in the presentation to the emergency room/delay in the administration of the intravenous antibiotics.^{21,22} In addition, there was increase in the readmission rates for the same time period in comparison to the previous year further corroborating the results. Also, increased infection rates were found in the Gustilo Anderson classification open grade 3 types in both the years for the same time period, corresponding to the previously mentioned results in the literature.^{19–25}

There was an increase in the external fixator application rate for the open fractures for the same time period compared to the previous year when nailing was done more, though the type of the open fractures according to the Gustilo Anderson classification remain the same as previous year. A possible explanation may be the less use of diathermy, power drills, reamed nailing and avoiding use of pulse lavage in order to reduce the aerosol generation and thus prevention of respiratory complications.²⁶

Despite the home quarantine and shutting down of schools, there was an increased rate of high energy trauma and thus the rate of open fractures in the children for the same time period when compared with the records of the previous year. A probable explanation for the same may be the child neglect at home which

might have led to the increased rate of accidents. Further, there was an absence of any outside oversight which may have increased the risk of fractures in children, though an exact reasoning couldn't be provided for the same.

While most of the current literature focuses on the COVID-19 disease itself, there have been few papers about the management of the fractures during the pandemic. Further, this study sheds light on the management of the open fractures and its short term outcome in this COVID-19 pandemic when the already compromised hospital resources are being overburdened by the additional readmission rates. Whenever the situation allows, we ought to consider careful methodologies and evidence based surgical techniques in which we are generally certain and with which we are recognizable to forestall blunder. Surgery should allow for immediate weight bearing and minimise prolonged best rest. In the current scenario the ideal hospital administrative protocol should be to acknowledge a sub-optimal result with the patient and avoid prolonged inpatient admission.

There are a number of limitations in the present study. Firstly this study is a retrospective study. Secondly, it provides a picture of a limited timeframe. Thirdly, this was a single centre study with a small number of subjects. Fourth, the influence of patient-related factors such as smoking, deranged blood sugar levels, etc.; type of fracture (severity and location of the lesion) and type of surgery (surgeon's familiarity and knowledge, adequate debridement of necrosed tissues and timing of the surgery) cannot be ruled out, which were not considered in the present study. Regardless of that, this study provides an overview on recent impact of the COVID-19, on surgical management of orthopaedic surgeries besides enlightening the overall impact on healthcare facilities. Further, it focuses on the social and monetary issues, that a cataclysmic circumstance, for example, Covid-19 episode may have on medical services.

Author's Perspective: The common reasons for delayed presentation to the tertiary care centres which were observed in this study include: lack of public transportation services between intra-state and interstate regions; conversion of more and more healthcare facilities in neighbouring states to dedicated COVID-19 centres; engagement of orthopaedicians in COVID-19 related duties in small healthcare facilities, where already number of surgeons are less and financial implications during this lockdown period. This further led to delay in giving the first dose of the intravenous antibiotic. In addition, COVID-19 testing by RT-PCR takes around 6–8 h to come which further led to delay in the wound debridement. With the majority of anaesthetists and surgeons being shifted to COVID-19 related duties, there was limited number of healthcare staff who were managing the emergency cases, which led to the increase in the number of pending cases and thus a delay in the surgical intervention. According to authors, streamlining of the transportation services, early referrals to tertiary centre centres with better coordination of referrals between different states government and beforehand intimation may prevent unnecessary delays and possible management at local healthcare facilities is the need of the hour, which may help prevent the complications.

5. Conclusions

Despite the decrease in total trauma cases in this unprecedented COVID-19 scenario, a delay in presentation to the emergency room/administration of first dose of antibiotic and increase in temporary fixation in form of external fixator was observed. Further, an increase in total infection rates, referral cases and 30 days readmission rate were observed, though not statistically significant.

Funding

No funds received.

Ethical approval

Institutional ethical committee approval was taken before the start of research.

Author's credit statement

Ravi Gupta: Conceptualization; Akash Singhal: Wrote Original Manuscript; Anil Kapoor: Methodology; Mehar Dhillon: review of literature; Gladson david: editing of the manuscript.

Declaration of competing interest

No conflict of interest for any author.

References

- Jain VK, Vaishya R. COVID-19 and orthopaedic surgeons: the Indian scenario. *Trop Doct.* 2020;50(2):108–110. <https://doi.org/10.1177/0049475520921616>.
- Ambrosio L, Vadalà G, Russo F, Papalia R, Denaro V. The role of the orthopaedic surgeon in the COVID-19 era: cautions and perspectives. *J Exp Orthop.* 2020;7(1):35. <https://doi.org/10.1186/s40634-020-00255-5>.
- Kumar Jain V, Lal H, Kumar Patralekh M, Vaishya R. Fracture management during COVID-19 pandemic: a systematic review. *J Clin Orthop Trauma.* 2020;11:S431–S441. <https://doi.org/10.1016/j.jcot.2020.06.035>.
- Titler MG. *The Evidence for Evidence-Based Practice Implementation.* Agency for Healthcare Research and Quality (US); 2008. Accessed <http://www.ncbi.nlm.nih.gov/pubmed/21328760>. Accessed September 7, 2020.
- Grock A, Rezaie S, Swaminathan A, Min A, Shah KH, Lin M. Blog and podcast watch: orthopedic emergencies. *West J Emerg Med.* 2017;18(3):531.
- Mundi R, Chaudhry H, Niroopan G, Petrisor B, Bhandari M. Open tibial fractures: updated guidelines for management. *Jbjs Rev.* 2015;3(2):1–7.
- Melvin SJ, Dombroski DG, Torbert JT, Kovach SJ, Esterhai JL, Mehta S. Open tibial shaft fractures: I. Evaluation and initial wound management. *Am Acad Orthop Surg.* 2010;18(1):10–19. <https://doi.org/10.5435/00124635-201001000-00003>.
- Petrisor BA, Bhandari M, Schemitsch E, Buchholz RW, Heckman JD, Court-Brown, C Tornetta PA 3rd. Tibia and Fibula Fractures. Rockwood and Green's Fractures in Adults. 7th ed Philadelphia. Published online 2010.
- Iyengar KP, Jain VK, Vaish A, Vaishya R, Maini L, Lal H. Post COVID-19: planning strategies to resume orthopaedic surgery—challenges and considerations. *J Clin Orthop Trauma.* 2020;11(3):S291–S295. <https://doi.org/10.1016/j.jcot.2020.04.028>.
- Nuñez JH, Sallent A, Lakhani K, et al. *Impact of the COVID-19 Pandemic on an Emergency Traumatology Service: Experience at a Tertiary Trauma Centre in Spain.* *Injury.* Published Online. 2020.
- Thakore RV, Francois EL, Nwosu SK, et al. The Gustilo–Anderson classification system as predictor of nonunion and infection in open tibia fractures. *Eur J Trauma Emerg Surg.* 2017;43(5):651–656.
- Galvagno SM, Nahmias JT, Young DA. Advanced trauma life support® Update 2019: management and applications for adults and special populations. *Anesthesiol Clin.* 2019;37(1):13–32.
- Hoff WS, Bonadies JA, Cachecho R, Dorlac WC. Open fractures, prophylactic antibiotic use in — update — practice management guideline. *J Trauma.* 2011;70(3):751–754. Accessed <https://www.east.org/education/practice-management-guidelines/open-fractures-prophylactic-antibiotic-use-in-update>. Accessed September 7, 2020.
- Benazzo F, Rossi SMP, Maniscalco P, et al. The orthopaedic and traumatology scenario during Covid-19 outbreak in Italy: chronicles of a silent war. *Int Orthop.* 2020;44(8):1453–1459.
- Hernigou J, Morel X, Callewier A, Bath O, Hernigou P. Staying home during “COVID-19” decreased fractures, but trauma did not quarantine in one hundred and twelve adults and twenty eight children and the “tsunami of recommendations” could not lockdown twelve elective operations. *Int Orthop.* Published online. 2020:1.
- Müller SS, Sardenberg T, Pereira GJC, Sadatsune T, Kimura EE, Novelli Filho JLVB. Estudo epidemiológico, clínico e microbiológico prospectivo de pacientes portadores de fraturas expostas atendidos em hospital universitário. *Acta Ortopédica Bras.* 2003;11(3):158–169.
- Kumar G, Narayan B. *Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones. Retrospective and prospective analyses.* *Classic Papers in Orthopaedics.* Springer; 2014:527–530.
- Spencer J, Smith A, Woods D. The effect of time delay on infection in open long-bone fractures: a 5-year prospective audit from a district general hospital. *Ann R Coll Surg Engl.* 2004;86(2):108.

19. Fernandes M de C, Peres LR, Queiroz Neto AC de, Lima Neto JQ, Turfio FM, Matsumoto MH. Open fractures and the incidence of infection in the surgical debridement 6 hours after trauma. *Acta Ortopédica Bras.* 2015;23(1):38–42.
20. Chang Y, Kennedy SA, Bhandari M, et al. Effects of antibiotic prophylaxis in patients with open fracture of the extremities: a systematic review of randomized controlled trials. *JBJS Rev.* 2015;3(6).
21. Ketonis C, Dwyer J, Ilyas AM. Timing of debridement and infection rates in open fractures of the hand: a systematic review. *Hand.* 2017;12(2):119–126.
22. Schenker ML, Yannascoli S, Baldwin KD, Ahn J, Mehta S. Does Timing to operative debridement affect infectious complications in open long-bone fractures?: a systematic review. *JBJS.* 2012;94(12):1057–1064.
23. Kamat AS. Infection rates in open fractures of the tibia: is the 6-hour rule fact or fiction? *Adv Orthop.* 2011;2011.
24. Patzakis MJ, Harvey JRJP, Ivler D. The role of antibiotics in the management of open fractures. *JBJS.* 1974;56(3):532–541.
25. Dellinger EP, Miller SD, Wertz MJ, Grypma M, Droppert B, Anderson PA. Risk of infection after open fracture of the arm or leg. *Arch Surg.* 1988;123(11):1320–1327.
26. Sobti A, Fathi M, Mokhtar MA, et al. *Aerosol Generating Procedures in Trauma and Orthopaedics in the Era of the Covid-19 Pandemic; what Do We Know? Surg.* 2020. Published online.