



Contents lists available at ScienceDirect

Journal of Orthopaedics

journal homepage: www.elsevier.com/locate/jor

Chronicling the effect of COVID-19 on orthopedic literature

Ivan Z. Liu^a, Kevin Y. Wang^b, Joseph X. Robin^c, Ian McGeary^d, Kshipra Hemal^b,
Carter J. Boyd^{e,*}

^a The Medical College of Georgia, Augusta University, 1120 15th St, Augusta, GA, 30912, United States

^b Wake Forest School of Medicine, 475 Vine St, Winston-Salem, NC, 27101, United States

^c Department of Orthopedic Surgery, NYU Langone, 301 East 17th Street, Suite 1402, New York, NY, 10003, United States

^d Hackensack Meridian School of Medicine, 340 Kingsland St, Nutley, NJ, 07110, United States

^e Hansjörg Wyss Department of Plastic Surgery, NYU Langone, 222 East 41 Street, New York, NY, 10017, United States

ARTICLE INFO

Keywords

COVID-19
Pandemic
Bibliometric
Orthopedic surgery literature

ABSTRACT

Background: The novel coronavirus disease (COVID-19) has had a significant impact on orthopedic surgery practice, but there has been little investigation of the effects of COVID-19 on the orthopedic surgery literature. Additionally, because orthopedic research plays a vital role in physician education, changes to the characteristics and content of published literature can have lasting impacts on future teaching and learning. This paper represents the first known analysis of the COVID-19 pandemic's impact on peer-reviewed articles published in orthopedic surgery journals.

Methods: The 20 orthopedic journals with the highest impact factors in 2019, according to the *Journal Citation Reports*, were included in this study. Using PubMed and COVID-19 related keywords as well as manual screening, a final count of 199 articles were assessed for this study and subsequently sorted by country of origin, orthopedic subspecialty, article type, and general theme. Kruskal Wallis and Pearson's Chi-squared tests were used to analyze continuous and categorical variables, respectively.

Results: Fourteen journals published articles relating to COVID-19, representing 26 countries with the United States (37%) and United Kingdom (13%) publishing the greatest proportion of all COVID-19 articles. Sixty percent of publications discussed COVID-19's impact on the overall field of orthopedic surgery, with the remainder focusing on specific subspecialties. Forty-seven percent of publications were original research articles while 46% were editorials or commentaries. The median time to publication for all COVID-19 related articles was 24.5 days, compared to the 129 days reported for orthopedic journals prior to the COVID-19 pandemic ($p < 0.001$). In the first 100 articles published, 49% ($n = 49$) originated exclusively from United States institutions, whereas only 25% ($n = 25$) of the next ninety-nine articles had US-only institutions ($p < 0.001$).

Conclusions: The COVID-19 pandemic has significantly impacted the characteristics, content, and time to publication of the orthopedic surgery literature. The data and ideas presented in this paper should help streamline future, formal analysis on the lasting implications of COVID-19 on orthopedic surgery practice, teaching, and learning.

1. Introduction

Beginning in March 2020, the spread of the novel coronavirus disease (COVID-19) has severely impacted the practice of orthopedic surgery globally. This effect of COVID-19 on the clinical practice of orthopedics has been widely documented, from redeployment efforts to postponement of elective surgeries, changes to personal protective equipment (PPE) in trauma cases, and more. However, little is known

about the impact of COVID-19 on peer-reviewed articles published in the orthopedic surgery literature. With the pandemic representing a core topic of daily life and medical discourse amongst colleagues in 2020, it's hypothesized that COVID-19 also had a significant impact on the characteristics, content, and time to publication of the orthopedic surgery literature.

Additionally, orthopedic research is a primary source of education for orthopedic surgery residents, fellows, and attendings. As a result, any

* Corresponding author. Department of Plastic Surgery, NYU Langone, 222 East 41st Street, New York, NY, 10017-6739, United States.

E-mail address: carterjosephboyd@gmail.com (C.J. Boyd).

<https://doi.org/10.1016/j.jor.2021.07.016>

Received 29 May 2021; Accepted 20 July 2021

Available online 21 July 2021

0972-978X/© 2021 Professor P K Surendran Memorial Education Foundation. Published by Elsevier B.V. All rights reserved.

changes to peer-reviewed orthopedic publications can have far-reaching and long-standing effects on physician teaching and learning. Particularly, multi-institutional collaboration allows for the synthesis of new ideas from differing schools of thought while the time from submission to publication directly limits the speed of knowledge propagation and discussion. Contextualizing the COVID-19 pandemic’s potential implications on future education are thereby important not only for individual physician aptitude, but also broader orthopedic surgeon mentorship and patient outcomes.

The aim of this study was to characterize the influence of the COVID-19 pandemic on the orthopedic surgery literature and to discuss its future implications on practice, teaching, and information dissemination.

2. Materials and methods

The 20 orthopedic surgery journals with the highest impact factors in 2019, according to the *Journal Citation Reports*, were included for data collection in this study. A PubMed search was then performed on these journals, identifying a total of 7562 articles published in 2020. Initial screening of these articles was conducted using keywords “COVID”, “SARS”, “pandemic”, “corona”, “COVID-19”, “SARS-CoV-2”, “2019 nCoV”, and “2019 novel corona virus,” yielding a preliminary total of 257 articles related to COVID-19. To ensure accuracy, these articles were then manually screened by one reader to confirm that the topics were relevant to the pandemic, resulting in a final count of 199 (3%) COVID-19 related articles. All queries were performed in March 2021.

The final 199 articles were characterized by number of authors, number of institutions and time from submission to publication. Additionally, these articles were manually read and classified by country of origin, orthopedic subspecialty, article type, and general theme. Included orthopedic subspecialties were general, multiple, spine, sports, trauma, hand, foot and ankle, oncology, pediatrics, arthroplasty, and other. Article types included original research articles, commentaries, perspective, or letter to the editor, guidelines, and other. Original research articles were further subclassified into retrospective cohort, cross-sectional, survey, case report, systematic or literature review, or other. General themes included healthcare delivery, business/economics, global responses to pandemic, complications in orthopedics

patients with COVID-19, changes to trauma practice, changes to teaching and mentoring, and other.

Kruskal Wallis and Pearson’s Chi-squared tests were used to analyze continuous and categorical variables, respectively.¹ A significance cut-off was set at a p-value < 0.05.

3. Results

Fourteen journals published articles relating to the COVID-19 pandemic, with the *Journal of Bone and Joint Surgery* publishing the greatest proportion of all COVID-19 articles, followed closely by *International Orthopaedics* (25% and 22%, respectively). Twenty-six countries were represented in authorship, with the most frequent being the United States (37%, n = 74), the United Kingdom (13%, n = 25), and Italy (7%, n = 13). Eighteen percent of publications (n = 36) had authorship with more than one country of origin. There were 19 first authors who collectively accounted for 22% of the COVID-19 related literature in orthopedic surgery. The mean number of authors per article was six and mean number of institutions per article was three.

Sixty percent of publications discussed the impact of COVID-19 on the overall field of orthopedic surgery, while the remainder discussed its effects on specific subspecialties, including trauma (19%), arthroplasty (11%), spine (4%), and sports (2%), among others. Forty-seven percent (n = 92) of publications were original research articles, 46% (n = 90) were editorials or commentaries, and 8% (n = 16) were guideline articles (Fig. 1). Of the original articles, 29% (n = 27) were retrospective cohort studies, 21% (n = 19) surveys, 19% (n = 17) reviews, and 8% (n = 7) case reports.

The mean time from submission to online or print publication for COVID-19 related articles was 31 days (n = 98), with no difference between original articles, editorials/commentaries, or guidelines (p > 0.05). However, the median time to publication of 24.5 days for all articles is faster than the median time to publication of 129 days reported for orthopedic journals prior to the COVID-19 pandemic (p < 0.001).^{2,3} The month of April 2020 had the greatest number of articles published (56), with progressively lower numbers of publications in every month thereafter (Fig. 2). The peak of number of publications in April occurred one month after the first global peak in COVID-19 cases in March 2020. The average length for all manuscripts was 2317 words long, and the

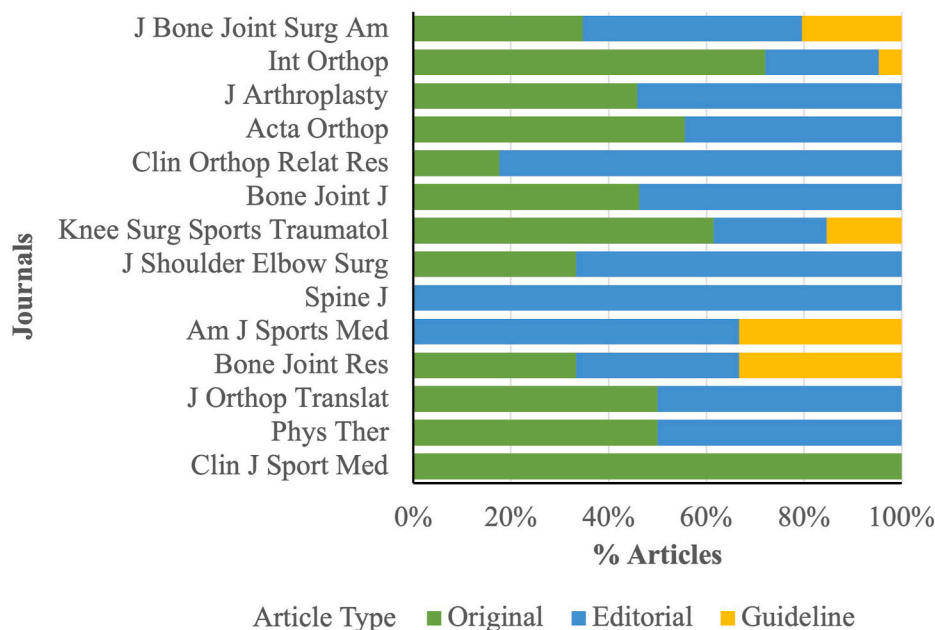


Fig. 1. stacked bar chart illustrating the proportion of general article types in each of the 14 orthopedic journals included in the study that published COVID-19 related articles.

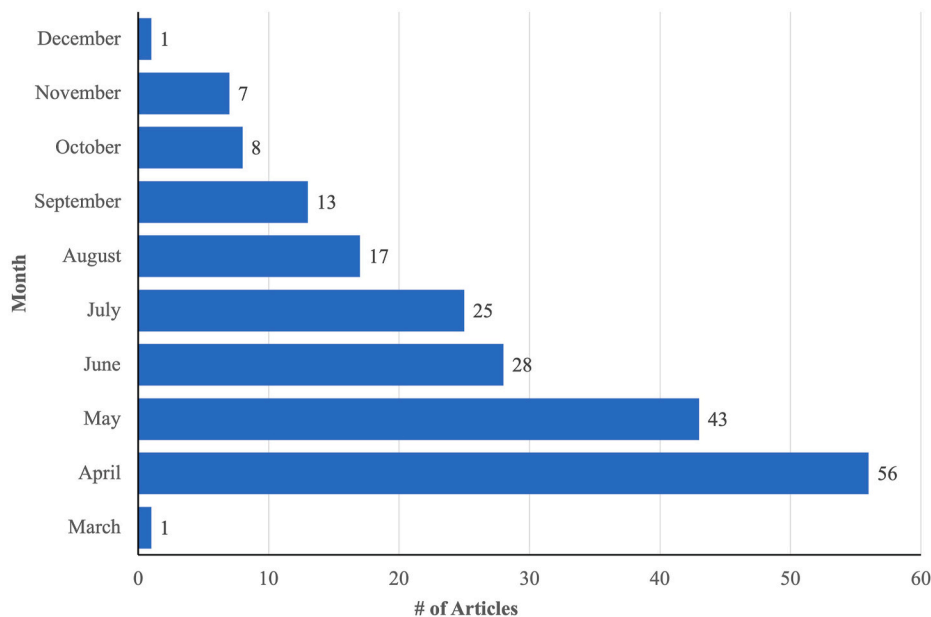


Fig. 2. Bar graph illustrating the number of COVID-19 related orthopedics articles published during each month of 2020.

average number of references was 19.

Analysis of the themes of each COVID-19 publication demonstrated that nearly all COVID-19 related articles in the orthopedic literature (98%, $n = 195$) discussed changes in healthcare delivery. Sixty-seven percent ($n = 134$) of all COVID-19 related articles fell under the theme of “global response to the pandemic,” meaning they discussed the varying approaches taken by different countries in response to COVID-19. Fifty two percent ($n = 103$) examined changes to orthopedic trauma practice. Twenty seven percent ($n = 53$) covered changes to orthopedic teaching and mentoring during the pandemic, meaning they discussed residency and fellowship suspensions and implementation of videoconferencing software. For the first thirty articles published, a dominant theme was firsthand accounts of the orthopedic experience during COVID-19, with 70% ($n = 21$) of these articles being classified as commentaries/editorials and 27% ($n = 8$) original research articles. In the next thirty articles published, only 40% ($n = 12$) were commentaries/editorials and 47% ($n = 14$) original research articles ($p < 0.05$). Additionally, of the first 100 articles published, 60% examined the global response to the pandemic, compared to 75% of the next 99 articles ($p < 0.05$). Similarly, in the first 100 articles published, 49% ($n = 49$) originated exclusively from the United States, whereas only 25% ($n = 25$) of the next ninety-nine articles had US-only institutions ($p < 0.001$).

4. Discussion

During the COVID-19 pandemic, orthopedic surgeons demonstrated innovation by creating novel personal protective equipment, adaptability when elective surgeries were postponed, and selflessness when redeployed to meet the changing demands of the healthcare system.^{4–6}

The majority (70%, 14/20) of orthopedic journals included in this study published articles related to the COVID-19 pandemic, indicating an intentional focus amongst orthopedic surgery journals on sharing pertinent knowledge and valuable experience relating to COVID-19. Furthermore, the fact that the 14 journals represented 26 different countries of origin highlights the global emphasis of the pandemic and its highly disruptive impact on the normal practice of orthopedic surgeons. Particularly, 36 publications (18%) had more than one country of origin, which reinforces the idea that regardless of the institution or country, many orthopedic surgeons shared similar experiences in terms of difficulties and newfound, required flexibility in operating during the

pandemic.

Because orthopedics is typically not directly involved in the care of COVID-19 patients, it follows logically that the majority (60%) of orthopedic publications discussed COVID-19’s impact as relating to the practice and experience of general orthopedic surgery. Additionally, the finding that orthopedic trauma (19%) had the most publications compared to any other subspecialty is consistent with the fact that trauma cases remain unavoidable and inherently emergent, even during a global pandemic. As such, this finding suggests that trauma orthopedic surgeons were more likely than other subspecialty surgeons to quickly seek out pertinent clinical data and changes to guidelines for trauma practice during the pandemic. Interestingly, the relatively equal proportion of original research articles (47%, $n = 92$) vs. editorials or commentaries (46%, $n = 90$) seems to further imply a relatively equal demand by orthopedic surgeons for both clinical data and anecdotal perspective pertaining to the pandemic.

Orthopedic surgery journals and their editorial teams also deserve immense praise during this time for their integral role in expediting review and publishing timelines from a median time of 129 days–24.5 days during the pandemic.⁷ This added efficiency allowed for not only the quickest dissemination of pertinent knowledge relating to COVID-19 and orthopedics, but also the unified and continued advancement of the overall field of orthopedic surgery in a time of limited in-person collaboration. At the same time, the downward trending number of orthopedic publications relating to COVID-19 per successive month in 2020 (Fig. 2) demonstrates a decreased research focus on the pandemic as the year progressed, potentially due to a combination of reader, researcher, and writer fatigue and a diminishing quantity of new clinical insights relating to the COVID-19 pandemic.

Nearly all COVID-19 orthopedic papers examined healthcare delivery (98%, $n = 195$ articles) while 67% of the orthopedic articles additionally discussed global responses to the pandemic. This illustrates an almost universal and global dialogue by orthopedic researchers on the pandemic’s impact on patient outcome and patient satisfaction as well as continued discourse on the best mechanism for delivering orthopedic care after the pandemic, including adoption of virtual technology and improved PPE.^{4,8} There was an early predomination of commentaries and editorials in the first 30 articles (70%, $n = 21$), but the proportion of original research articles increased in the next 30 publications (47%, $n = 14$, $p < 0.05$). Specifically, articles published earlier in the pandemic focused on quickly sharing firsthand

perspectives on life as an orthopedic surgeon during the pandemic in regions of the world affected earlier and more severely, so that orthopedic surgeons in later and less affected areas around the world could better prepare themselves for the coming demands.

Importantly, 27% of all COVID-19 papers discussed changes to teaching and mentoring, stressing the orthopedic community's close attention to maintaining the rigorous education of orthopedic surgeons and learning from the experiences of the pandemic to improve future teaching and learning. The COVID-19 pandemic stimulated creative and novel solutions for maintaining rigorous orthopedic surgery training, including virtual journal clubs, video-based learning, and simulated virtual reality cases.^{8–11} A number of orthopedic articles further discussed the added value of a hybrid virtual and in-person approach to residency and fellowship education after the pandemic, while surveys of orthopedic surgeons demonstrated a consistently positive opinion on specifically continuing virtual seminars with audience interaction and online case presentations.^{11–13} Some articles also emphasized the utility of videoconferencing in bolstering information dissemination and networking, which allowed for increased exposure to thought leaders around the world and easier multi-institution research.^{10,14} For example, the increasingly international research focus and collaboration (49% US-only institutions in first 100 articles vs. 25% in next 99 articles) hints at the potential for a future with sustained, increased interconnectivity, a novel way of leveling and raising the overall playing field of orthopedics. On the other hand, a handful of new practices were poorly received by residents, including online tests, virtual patient consultations, and non-standardized interview processes for residency recruitment, indicating any continued implementation of these measures should be approached with caution.^{12,15} In a post-COVID-19 world, it remains to be seen how the nature of a hybrid integration will develop with regards to teaching and learning.

One limitation of this study was the subjectivity in determining the general themes of each article, which required manually reading each publication. To address this concern, the study employed only one reader for all 199 publications in order to eliminate inter-reviewer variability and minimize inconsistency in subjective measures. Additionally, because only one research database (PubMed) and a selection of orthopedic journals were included in this study, a further limitation is generalizing these trends to the entirety of the orthopedic literature. However, data analysis indicated that the sample size and distribution had sufficient statistical power for the purposes of this study. Further research should focus on the lasting effects of the COVID-19 pandemic on orthopedic surgery, with particular emphasis on the optimization of telehealth and videoconferencing for patient care, future practice of teaching and learning, and research collaboration.

5. Conclusions

This study characterized the influence of the COVID-19 pandemic on the orthopedic surgery literature and discussed its future implications on practice, teaching, and information dissemination. Moving forward, the impact of the COVID-19 pandemic on the orthopedic surgery community will forever be preserved in the research literature.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author contributions

Ivan Liu: Formal analysis; Investigation; Visualization; Writing –

original draft, Writing – review & editing. Kevin Wang: Data curation; Supervision; Validation; Writing – review & editing. Joseph Robin: Data curation; Supervision; Validation; Writing – review & editing. Ian McGeary: Visualization; Writing – review & editing. Kshipra Hemal: Conceptualization; Data curation; Formal analysis; Methodology; Software; Visualization; Writing – review & editing. Carter Boyd: Conceptualization; Data curation; Methodology; Project administration; Supervision; Validation; Writing – review & editing.

Declaration of competing interest

None.

Acknowledgements

None.

References

- Hemal K, Boyd CJ, Cuccolo NG, Saadeh PB. Chronicling the COVID-19 pandemic through the plastic surgery literature. *J Plast Reconstr Aesthetic Surg.* 2021;(21): S1748–S6815. <https://doi.org/10.1016/j.jbips.2021.01.013>. Feb 5.
- Charen DA, Maher NA, Zubizarreta N, Poeran J, Moucha CS, Shemesh S. Evaluation of publication delays in the orthopedic surgery manuscript review process from 2010 to 2015. *Scientometrics.* 2020;124(1):1127–1135. <https://doi.org/10.1007/s11192-020-03493-7>.
- Wan X, Wang W, Liu J, Tong T. Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. *BMC Med Res Methodol.* 2014;14(1):135. <https://doi.org/10.1186/1471-2288-14-135>.
- Erickson MM, Richardson ES, Hernandez NM, Bobbert 2nd DW, Gall K, Fearis P. Helmet modification to PPE with 3D printing during the COVID-19 pandemic at Duke University medical center: a novel technique. *J Arthroplasty.* 2020;35(7S):S23–S27. <https://doi.org/10.1016/j.arth.2020.04.035>.
- Brown TS, Bedard NA, Rojas EO, et al. The effect of the COVID-19 pandemic on electively scheduled hip and knee arthroplasty patients in the United States. *J Arthroplasty.* 2020;35(7S):S49–S55. <https://doi.org/10.1016/j.arth.2020.04.052>.
- Sarpong NO, Forrester LA, Levine WN. What's important: redeployment of the orthopaedic surgeon during the COVID-19 pandemic: perspectives from the trenches. *J Bone Joint Surg Am.* 2020;102(12):1019–1021. <https://doi.org/10.2106/JBJS.20.00574>.
- Swiontkowski M. COVID-19 pandemic and JBJS. *J Bone Joint Surg Am.* 2020;102(9): 733. <https://doi.org/10.2106/JBJS.20.00471>.
- Siddiqi A, Chen AF, Schwarzkopf R, Springer BD, Krebs VE, Piuizzi NS. Evaluating the fellowship experience during COVID-19: adult joint reconstruction. *J Arthroplasty.* 2020;35(8):1959–1961. <https://doi.org/10.1016/j.arth.2020.06.031>.
- Chang DG, Park JB, Baek GH, et al. The impact of COVID-19 pandemic on orthopaedic resident education: a nationwide survey study in South Korea. *Int Orthop.* 2020;44(11):2203–2210. <https://doi.org/10.1007/s00264-020-04714-7>.
- Stambough JB, Curtin BM, Gililand JM, et al. The past, present, and future of orthopedic education: lessons learned from the COVID-19 pandemic. *J Arthroplasty.* 2020;35(7S):S60–S64. <https://doi.org/10.1016/j.arth.2020.04.032>.
- Hedman LR, Felländer-Tsai L. Simulation-based skills training in non-performing orthopedic surgeons: skills acquisition, motivation, and flow during the COVID-19 pandemic. *Acta Orthop.* 2020;91(5):520–522. <https://doi.org/10.1080/17453674.2020.1781413>.
- Figuerola F, Figuerola D, Calvo-Mena R, Narvaez F, Medina N, Prieto J. Orthopedic surgery residents' perception of online education in their programs during the COVID-19 pandemic: should it be maintained after the crisis? *Acta Orthop.* 2020;91(5):543–546. <https://doi.org/10.1080/17453674.2020.1776461>.
- Scarlat MM, Sun J, Fucs PMB, et al. Maintaining education, research and innovation in orthopaedic surgery during the COVID-19 pandemic. The role of virtual platforms. From present to virtual, front and side effects of the pandemic. *Int Orthop.* 2020;44(11):2197–2202. <https://doi.org/10.1007/s00264-020-04848-8>.
- Jones SD, Thon S, Frank RM. Shoulder and elbow education during COVID-19: perspectives from the resident, fellow, and attending level. *J Shoulder Elbow Surg.* 2020;29(7):1297–1299. <https://doi.org/10.1016/j.jse.2020.04.017>.
- Dattani R, Morgan C, Li L, Bennett-Brown K, Wharton RMH. The impact of COVID-19 on the future of orthopaedic training in the UK. *Acta Orthop.* 2020;91(6):627–632. <https://doi.org/10.1080/17453674.2020.1795790>.