EJMA

DOI: 10.14744/ejma.2023.44154
EJMA 2023;3(2):70–78

Research Article

Orthopedic Consequences of Post-COVID-19 High-dose Corticosteroid Use and Vaccination: An Update Study

Necdet Demir

Department of Orthopaedics and Traumatology, Biruni University Faculty of Medicine, Istanbul, Türkiye

Abstract

Objectives: To update top-cited articles on the complications of high-dose corticosteroid use and vaccination-related avascular osteonecrosis after COVID-19.

Methods: Obtaining top-cited articles on the theme of 'COVID-19 avascular necrosis' from Web of Science and determining the evidence levels according to the complication topics of these trending topic articles, along with the evaluation of Altmetric Attention Score (AAS) and Dimensions badges via 'Altmetric it', to determine correlation analysis between publication metrics.

Results: Trending topic articles on early orthopedic complications of post-COVID-19-related high-dose steroid use have increased since 2020 and especially peaked in 2022. It is also noteworthy that the mesotopic is orthopedics and the microtopic is coronavirus. Besides, the complication most frequently mentioned in trending topic articles is femoral head avascular necrosis, and the majority of articles have evidence level 3 by SIGN100. The distribution range of AAS was especially large, while the total citation number (4.1±8.2) and average citation per year (1.6±2.7) were also slightly low. Moderately positive, statistically significant correlations were detected between the AAS, average citation per year, and total citation number ($p<0.05$).

Conclusion: The most common osteonecrosis associated with post-COVID-19 high-dose corticosteroid use is unilateral femoral head avascular necrosis, and care should be taken in treatment.

Keywords: COVID-19, high-dose corticosteroid use, vaccination, avascular osteonecrosis

Cite This Article: *Demir N. Orthopedic Consequences of Post-COVID-19 High-dose Corticosteroid Use and Vaccination: An Update Study. EJMA 2023;3(2):70–78.*

COVID-19, which spread from Wuhan, China, to the whole world in the last half of 2019 and turned into a pandemic, has brought with it many different and mostly dramatic consequences.[1, 2]

Osteonecrosis, or avascular necrosis, which is one of the most important of these in terms of its consequences and gradually increases during the pandemic period, develops due to the use of high-dose or pulse corticosteroids (methyl prednisolone equivalences: 10 mg/kg/day, up to 3 days) in patients with severe and critical COVID-19 and is frequently seen in the femoral head and unilaterally, less commonly bilaterally (Fig. 1).[3-6]

Treatment of femoral head avascular necrosis is mostly medical. However, depending on the stage of the avascular necrosis, surgery may range from percutaneous drilling, core decompression (with/without stem cell augmentation), bone grafting, and osteotomy (location-based) (Pre-collapse of femoral head as radiological presentation; Ficat stage I-II, ARCO stage I-II, UPenn stage 0-I-II-III) to total definite hip arthroplasty (Collapse of femoral head as radiologi-

Address for correspondence: Necdet Demir, MD. Department of Orthopaedics and Traumatology, Biruni University Faculty of Medicine, Istanbul, Türkiye
Phone: +90 212 411 39 00 **E-mail:** drnecdetdemir28@gmail.com

Submitted Date: September 06, 2023 **Accepted Date:** October 12, 2023 **Available Online Date:** October 26, 2023

©Copyright 2023 by Eurasian Journal of Medical Advances - Available online at www.ejmad.org
OPEN ACCESS This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

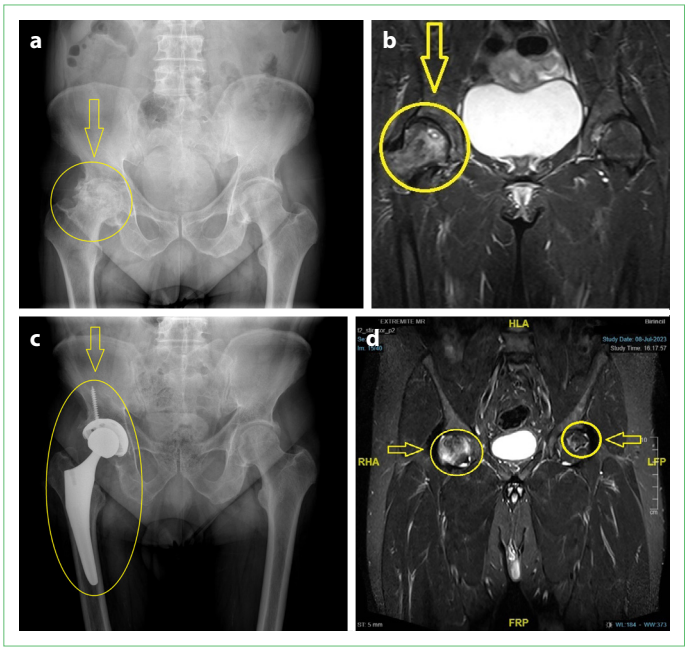

Figure 1. Unilateral and bilateral avascular necrosis of the femoral head (A, B, C, and D, respectively) as a complication of post-COVID-19 high-dose (pulse) steroid use: **(a)** Development of right coxarthrosis (hip osteoarthritis) due to osteonecrosis in pre-surgical X-ray imaging **(b)** On a pre-surgical MRI of the hip, there is an area of osteonecrosis of the femoral head. In the coronal section, there is widespread bone marrow edema around the acetabulum and more effusion in the joint. **(c)** X-ray imaging after total hip replacement for the treatment of coxarthrosis due to avascular necrosis **(d)** Coronal section evaluation in hip joint MRI imaging of another patient; there is active medullary bone marrow edema around areas of osteonecrosis in the right hip joint. The borders of the osteonecrosis area in the left hip joint are well defined, and there is bone marrow edema around the osteonecrosis area.

cal presentation; Ficat stage III-IV, ARCO stage IIIA-IIIB-IV / UPenn stage IV-V-VI).[7, 8]

As of now, knee and jaw osteonecrosis as a postacute avascular osseous sequela due to pulse corticosteroid use in COVID-19 patients and femoral avascular necrosis due to COVID-19 vaccination have also been reported.[9-11]

We conducted both citation and social attention-based analyses of these trending topical articles, the main theme of which is avascular osseous complications caused by high-dose corticosteroid use after COVID-19 in severe and critical patients.

Methods

Study Design

Study type: Retrospective clinical research.

Level of evidence in this study: Level 3 of Group B, according to the Scottish Intercollegiate Guidelines Network SIGN100.[12]

Article Selection and Data Collection

The data for this publication was obtained from the Web of Science (WoS) Core Collection database (Philadelphia, Pennsylvania, the US) using "COVID-19 avascular osteonecrosis" as a search term (accessed September 14, 2023). The articles published on post-COVID-19-related avascular osteonecrosis due to high-dose corticosteroid use between 2020 and 2023 were selected. Full-text articles were gathered and sorted according to the number of citations for each article. Simultaneously, we performed altmetric score analysis and Dimensions badges of topic trending articles via 'altmetric it' to measure the Altmetric Attention Score (AAS) of the top-cited 33 articles list (https://www.altmetric.com/) and (https://badges.dimensions.ai/) (accessed September 14, 2023).

Publication Metrics Analysis

The analysis results and citation reports of 33 top-cited articles obtained from WoS were evaluated. In this context, with the data obtained from WoS, trending topic articles, journal metrics, citation topics (meso and micro), publication and document types, languages, WoS Index, sustainable development goals, total citation number and average citation per year, first authors, and total number, Results such as authors, times cited, and publications over time were achieved.To obtain publication metrics other than WoS, we used a methodology that defined AAS as the weighted average of all the attention each paper received. On the altmetric spheroid, each color represents a unique region requiring attention. Furthermore, the quantity of tweets correlated with every article was documented. Dimensions badges are interactive displays of citation data for specific publications. Each publication in the Dimensions database

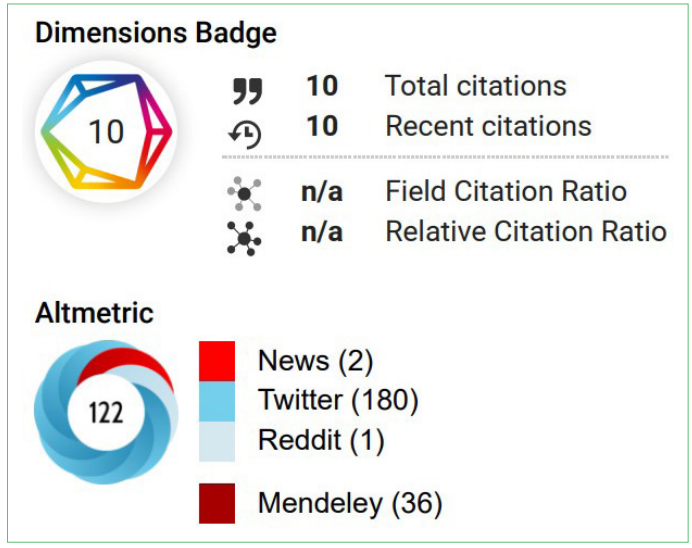

Figure 2. Publication metrics examples (Altmetric donut and Dimensions badge).

has its own badge (Fig. 2).[13, 14] Additionally, we determined the correlation analysis between the obtained publication metrics (TCN, ACpY, AAS, and Dimensions).Beyond these, we have classified the complications that form the main theme of 33 top-cited articles into levels of evidence by SIGN100 (1 to 4).

Statistical Analysis

Descriptive statistics were performed; mean±SD/Median Quartile 1 and 3 for numerical and number/percentage for categorical values are given. Comparing altmetric, total citations, tweets, and dimensions-badge values made use of the Kruskal-Wallis, while the Dunn test handled post-hoc analyses. Spearman or Pearson correlation coefficients were calculated to detect a linear relationship between numerical variables. Beta coefficients were estimated by univariate linear regression analysis. All statistical analyses were performed using the SPSS (Statistical Package for the Social Sciences, SPSS Inc., Chicago, IL, USA) 21.0 package program and p-values.

Results

It is interesting to note that trending topic articles on early orthopedic complications of post-COVID-19-related high-dose steroid use have grown since 2020 and especially peaked in 2022 (17 articles, 51.5% of all articles reviewed). We also found that citations to publications increased at the same rate as the increase in publications (Fig. 3). After looking at the top-cited 33 articles we used in the study, we found that their Altmetric attention score (AAS), Dimensions badge, total citation number (TCN), and average citation per year (ACpY) were all relatively low. The AAS distribution range was especially large, while TCN (4.1±8.2) and ACpY (1.6±2.7) were also slightly low. When the AAS subcomponents were examined, it was noted as a remarkable finding that the most frequent use of the popular articles included in our study was Twitter posts and Mendeley (Reference Management Software). Although the number of case reports and case series as document types of articles is relatively higher than original articles (n=14, 42.4%, and n=7, 21.2%, respectively), it is noteworthy that more than half of the articles (n=18, 54.5%) are published in journals whose Web of Science (WoS) indexes are SCI-Expanded. It is noteworthy that almost all publication types are open access (n=28, 84.9%) and languages are English (n=30, 90.9%). It was determined that almost all of the publication types were open access (n=28, 84.9%), their languages were English (n=30, 90.9%), and the sustainable development goals were "good health and well-being" (n=31, 93.9%). When looking at the citation topic distribution of popular articles, it is noteworthy that the meso topic is orthopedics and the micro topic is coronavirus (Table 1).

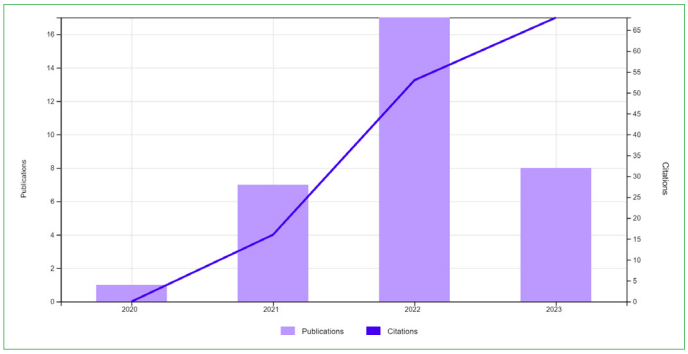

Figure 3. Times cited and publications over time (n=33).

When trending topic articles were examined in terms of journal metrics, it was seen that although their H indexes were relatively high, journals with Q2 and impact factors below 1 were When trending topic articles were examined in terms of journal metrics, it was seen that although their H indexes were relatively high, journals with Q2 and impact factors below 1 were weighted (median values: [46], [2], and [0.6], respectively). When the most-read articles on avascular necrosis related to COVID-19 were compared to the types of journals they were published in, orthopedic journals came out on top. General medicine journals like Cureus and infectious diseases journals came in second and third, respectively. When the article is evaluated in terms of authors, it is noticed that the majority of articles with four authors are present. In addition, Agarwala SR (India) attracts attention as the first author with two articles on post-COVID-19-related osteonecrosis. Following this are Phansopkar P (India) and Vijayvargiya M (India), who are co-authors of two articles each (Table 1 and Table 2).

When we looked at the relationship between publication metrics of popular papers on osteonecrosis after COVID-19, we found a strong positive statistically significant correlation between total citation number (TCN) and average citation per year (ACpY) ($r=0.979$; $p=0.001$). The increase in the number of tweets causes an increase in the Altmetric score (AAS). Moderately positive, statistically significant correlations were detected between AAS, ACpY, and TCN ($p<0.05$). Statistically significant positive correlations were detected between Dimensions badges and TCN, ACpY, and AAS ($p<0.001$) (Table 3).

In terms of complications related to post-COVID-19 pulse steroid treatment or active immunization, it is noteworthy that the complication most frequently mentioned in trending topic articles is femoral head avascular necrosis, and the majority of articles with evidence level 3 by SIGN100 are noteworthy, and the rates for both were 18 (54.6%). (Table 4).

Table 1. General characteristics of trending topic articles

Parameters	Mean±SD	Median	Min-Max	Total
Publication metrics				
Altmetric attention score	17.4±38.7	[2]	0-164	564
Twitter	25.5±65.5	[2]	0-323	843
Mendeley	18.7±25.6	[11]	0-96	618
Dimensions badge	6.9±13.6	[1]	0-69	227
Total citations	4.1±8.2	[2]	0-42	137
Average citation per year	1.6±2.7	[1]	0-14	52
Journal metrics				
H-Index	62.7±67	[46]	0-372	2059
Quartile (Q)	1.6±1.1	[2]	0-4	52
Impact Factor (IF)	0.8±0.7	[0.6]	0-4	25.5
Number of authors	4.5±1.9	[4]	2-8	150
Citation Topics Meso	→	**% of 33**	←	**Citation Topics Micro**
1.34 Orthopedics	→	28 (84.9)	←	1.104.1353 Coronavirus
1.6 Immunology	→	1 (3)	←	1.6.2262 Neu. E.T.
*DNCDA	→	2 (6.1)	←	*DNCDA
Publication Types	**% of 33**			
All Open Access	28 (84.9)			
*DNCDA	5 (15.1)			
Document Types	**% of 33**			
Case report/series	14 (42.4)			
Original Article	7 (21.2)			
Literature review	6 (18.2)			
Editorial material	5 (15.2)			
Meeting abstract (case rep.)	1 (3)			
Languages	**% of 33**			
Engilish	30 (90.9)			
Russian	3 (9.1)			
Web of Science Index	**% of 33**			
(SCI-Expanded)	18 (54.5)			
(ESCI)	15 (45.5)			
Sustainable Development Goals	**% of 33**			
03 Good Health and Well Being	31 (93.9)			
*DNCDA	2 (6.1)			

SD: standard deviation; Neu. E.T.: Neutrophil Extracellular Trap; *DNCDA: Do not contain data in the field being analyzed.

Discussion

The rapid increase in the number of published articles and citations regarding osteonecrosis caused by the use of high doses of corticosteroids in the treatment of COVID-19 can be attributed to the long duration and lethality of the pandemic as well as a better understanding of complications related to treatment and vaccination. A 'Long COVID-19' period has now been defined, which has surrounded every aspect of life and is full of COVID-19-related post-acute sequelae and complications.[15,16]

Social attention analyses such as social attention-based Almetric analysis and weighted citation-based Dimensions badges, which are proposed as an alternative to classical citation-based article evaluation, can be an important tool for detecting changing trending topics in scientific articles.[17, 18] The fact that the meso and microcitation topics of the COVID-19-related avascular osteonecrosis articles we found in Web of Science (WoS) are "Orthopedics" and "Coronavirus" shows that the articles

Table 2. Top-cited articles on post- COVID-19-related avascular necrosis by publication metrics

No	Title	First authors and TNoA	Journals	TCN	ACpY	AAS
1	Avascular necrosis as a part of 'long COVID-19' (2021)	Agarwala SR (3)	BMJ Case Reports (H: 37/Q3/IF: 0.26)	42	14	98
2	Beware of Steroid-Induced Avascular Necrosis of the Femoral Head in the Treatment of COVID-19-Experience and Lessons from the SARS Epidemic (2021)	Zhang S (4)	Drug Des Devel Ther (H: 82/Q1/IF: 0.89)	23	7.67	4
3	Avascular Necrosis Bone Complication after Active COVID-19 Infection: Preliminary Results (2021)	Sulewski A (7)	Medicina (Lithuania) (H: 52/Q2/IF: 0.59)	13	4.33	6
4	Long-term Outcome of Short-course High-dose Glucocorticoids for Severe Acute Respiratory Syndrome (SARS): A 17-Year Follow-up in SARS Survivors (2021)	Sing CW (5)	Clin Infect Dis (H: 372/Q1/IF: 4)	7	2.33	20
5	Orthopaedic Considerations Following COVID-19: Lessons from the 2003 SARS Outbreak (2020)	Patel MS (3)	JBJS Rev (H: 32/Q1/IF: 0.91)	7	1.75	0
6	Post-COVID-19 related osteonecrosis of the jaw (PC-RONJ): an alarming morbidity in COVID-19 surviving patients (2022)	Al-Mahalawy H (8)	BMC Infect Dis (H: 122/Q2/IF: 1.06)	6	3	122
7	COVID-Associated Avascular Necrosis of the Maxilla-A Rare, New Side Effect of COVID-19 (2022)	Manon VA (5)	J Oral Maxillofac Surg (H: 132/Q2/IF: 0.65)	4	2	1
8	Aggressive Presentation and Rapid Progression of Osteonecrosis of the Femoral Head After COVID-19 (2022)	Dhanasekararaja P (6)	Indian J Orthop (H: 38/Q3/IF: 0.38)	2	4	46
9	Secondary osteonecrosis of the knee as a part of long COVID-19 syndrome: a case series (2022)	Agarwala SR (3)	BMJ Case Reports (H: 37/Q3/IF: 0.26)	2	4	2
10	Orthopaedic long COVID - the unknown unknowns (2022)	Snowden GT (5)	Bone Joint Res (H: 42/Q1/IF: 1.61)	2	4	27
11	Double Trouble-COVID-19 and the Widespread Use of Corticosteroids: Are We Staring at an Osteonecrosis Epidemic? (2022)	Shetty GM (2)	Indian J Orthop (H: 38/Q3/IF: 0.38)	4	1.33	4
12	Undiagnosed Bilateral Avascular Necrosis of the Femur in a Young Male Caused by COVID-19 Steroid Injections (2022)	Kamani S (3)	Cureus (H: 46/Q-/IF: 1.2)	3	1.5	0
13	Avascular Necrosis in Patients Recovering from COVID-19 (2021)	Namiranian P (4)	Am J Med Sci (H: 97/Q2/IF: 0.66	3	1	5
14	Avascular Necrosis of the Hip: A Post COVID-19 Sequela (2022)	Kingma TJ (4)	Cureus (H: 46/Q-/IF: 1.2)	1	2	2
15	Corticosteroids induced avascular necrosis of hip, a long COVID-19 complication: Case report (2022)	Annam P (8)	Ann Med Surg (H: 36/Q3/IF: 0.39)	1	2	1
16	Concomitant septic arthritis of the hip joint and femoral head avascular necrosis in patients with recent COVID-19 infection: a cautionary report (2022)	Ardakani MV (7)	J Orthop Surg Res (H: 60/Q1/IF: 0.74)	1	2	1
17	Avascular Necrosis of the Femoral Head After COVID-19: A Case Series (2022)	Panin M (4)	Traumatology and Orthopedics of Russia (H: -/Q-/IF: -)	1	2	0
18	Corticosteroid induced avascular necrosis and COVID-19: The drug dilemma (2021)	Banerjee I (3)	Nepal J Epidemiol (H: 2/Q-/IF: 0)	0.67	2	0
19	Femoral head avascular necrosis in COVID-19 survivors: a systematic review (2023)	Hassan A (2)	Rheumatol Int (H: 85/Q2/IF: 1.03)	1	1	4
20	Post-COVID steroid induced avascular necrosis of the jaw: Emerging challenge in India (2023)	Sood A (5)	Oral Surg Oral Med Oral Pathol Oral Radiol (H: 133/Q2/IF: 0.56)	1	1	3
21	Osteonecrosis in Patients Recovering from COVID-19: Mechanisms, Diagnosis, and Treatment at Early-Stage Disease (Review) (2022)	Torgashin AN (2)	Traumatology and Orthopedics of Russia (H: -/Q-/IF: -)	0.5	1	0
22	Corticosteroid-Associated Avascular Necrosis of the Femoral Head in Patients with Severe COVID-19: A Single-Center Study (2023)	Velchov V (5)	Med Sci Monit (H: 97/Q2/IF: 0.63)	0	0	1

Table 2. Cont.

No	Title	First authors and TNoA	Journals	TCN	ACpY	AAS
23	Who is the convict; COVID-19 or corticosteroid? Late onset avascular necrosis of hips after COVID-19. A case report with literature review (2023)	Nejadhosseinian M (8)	Int J Rheum Dis (H: 51/Q3/IF: 0.72)	0	0	0
24	Dose-Response Meta-Analysis of Corticosteroid Effects in SARS Outbreak: A Model for Risk Stratification and Screening Strategy for Osteonecrosis of Femoral Head Post-Corticosteroid Therapy for COVID-19 (2023)	Muthu S (6)	Life (Basel) (H: 46/Q2/IF: 0.63)	0	0	0
25	Avascular Necrosis as a Sequela of COVID-19: A Case Series (2023)	Parikh S (6)	Cureus (H: 46/Q-/IF: 1.2)	0	0	3
26	Spontaneous Avascular Necrosis of the Humeral Head Following COVID-19 Vaccination (2023)	Kashkosh A (4)	Arch Bone Jt Surg (H: 26/Q2/IF: 0.42)	0	0	47
27	Physiotherapy Rehabilitation Post Total Hip Replacement in the Case of Avascular Necrosis of the Femur: A Case Report (2023)	Choubisa CA (3)	Cureus (H: 46/Q-/IF: 1.2)	0	0	0
28	Avascular necrosis - A complication of COVID-19 infection treatment (2022)	Tewatia P (2)	Indian J Rheumatol (H: 15/Q4/IF: 0.21)	0	0	2
29	Transient spontaneous osteonecrosis of the knee (SONK) shortly after SARS-CoV-2 infection: A report of 2 cases (2022)	Malinowski K (8)	Adv Clin Exp Med (H: 38/Q1/IF: 0.45)	0	0	1
30	Can COVID-19 cause Bilateral Femoral Head Avascular Necrosis Necrosis? Case Report (2022)	Ben Tekaya R (5)	Aging Clin Exp Res (H: 83/Q2/IF: 0.98)	0	0	0
31	Complications of Corticosteroid Therapy: A Comprehensive Literature Review (2022)	Koshi Elliott J (5)	J Pharm Technol (H: 14/Q3/IF: 0.24)	0	0	0
32	Postacute sequelae of SARS-CoV-2 infection. Osteonecrosis must not be overlooked (2022)	Koutalos AA (3)	Int J Infect Dis (H: 118/Q1/IF: 2.01)	0	0	164
33	Orthopedic Consequences of COVID-19 (2022)	Tikhilov RM (2)	Traumatology and Orthopedics of Russia (H: -/Q-/IF: -)	0	0	0

TNoA: Total number of authors; SJR: Scimago Journal & Country Rank (2022); TCN: Total citation number; ACpY: Average citation per year; AAS: Altmetric attention score.

Table 3. Correlation analysis between publication metrics

Variables (n=33)	ACpY	TCN	AAS
TCN			
r	0.979**		
p	<0.001		
AAS			
r	0.473*	0.420*	
p	0.005	0.015	
Dimensions badge			
r	0.781**	0.746**	0.742**
p	<0.001	<0.001	<0.001

ACpY: Average citation per year; TCN: Total citation number; AAS: Altmetric attention score; r was obtained from spearman rank or Pearson correlation coefficient (*p<0.05 and **p<0.001).

we chose are in line with how the pandemic is changing. Again, one of the results we obtained from WoS, which is that the development goals of most popular articles are 'Good Health and Wellbeing', is a good target desired and expected for scientific studies on the COVID-19 pandemic.[19] Twitter and Mendeley receive the majority of the social attention for the trending topic articles in our study, which may be due to the fact that scientists use these two social media platforms more frequently when sharing their scientific work.[20]

At the beginning of the pandemic, although there was no positive correlation between AAS and TCN for most COVID-19-themed articles, and although AAS was at the forefront of blogging and Twitter on scientific topics,[21] Dimensions badge and TCN, ACpY, and TCN were at the forefront for articles on COVID-19-related avascular osteonecrosis. The fact that there is a moderately significant positive correlation between AAS may be related to the fact that the discussion of treatment-related problems coincided with the later periods when pandemic-related criticisms were more discussed. Dimensions badge, total citation number, and average citation per year were all relatively low compared

Table 4. Post-COVID-19 high-dose corticosteroid use or vaccination-induced complications, according to the levels of evidence*

	Level of evidence				
Complications	**1**	**2**	**3**	**4**	**n (%)**
Spesific (osseous and articular)					
Corticosteroid induced AVN-FH	2	1	10	5	18 (54.6)
Corticosteroid induced AVN-FH and AVN-Kn	-	-	2	-	2 (6.1)
Corticosteroid induced AVN-Jw	-	-	2	1	3 (9.1)
Corticosteroid induced AVN-Kn	-	-	1	-	1 (3)
Corticosteroid induced AVN-FH and septic arthritis (hip)	-	-	1	-	1 (3)
COVID-19 vaccination induced AVN-FH	-	-	1	-	1 (3)
Non-spesific (general and extra-osseous)					
Corticosteroid induced AVN	-	1	1	4	6 (18.2)
Corticosteroid induced AVN and GIS bleedings	-	-	-	1	1 (3)
Total	2	2	18	11	33 (100)

*SIGN100: Scottish Intercollegiate Guidelines Network 2019; AVN: Avascular necrosis (general); AVN-FH: Avascular necrosis of the Femoral Head; AVN-Kn: Avascular necrosis of the Knee; AVN-Jw: Avascular necrosis of the Jaw; GIS: Gastrointestinal system.

to other COVID-19 articles on medical treatment and immunization.

While the agendas shared by scientists on social media and in the academy at the beginning of the COVID-19 pandemic were mainly diagnosis, treatment, transmission, and protection, in the later stages the main topics discussed were vaccination, while in the last phase the main issues discussed are now vaccine and treatment-related complications.[22-25] Post-COVID-19 high-dose corticosteroid use-related avascular osteonecrosis is a typical example of this.

In 2020, WHO issued technical guidelines that limited the use of corticosteroids in treating COVID-19 patients (severe/critical patients and up to 7–10 days). However, during the height of the COVID-19 pandemic, avascular osteonecrosis was thought to be the long-term effect of high-dose corticosteroid use to protect against the damaging effects of cytokine storms, especially in severe and critical patients, and it got worse over time.[26-30] According to the treatment guidelines for high-dose steroid use, over 250 mg of methyl prednisolone equivalents daily parenterally and for 3 days is recommended in severe and critical adult patients with COVID-19. However, in most of the cases in which avascular necrosis developed in the articles included in our study, over 750 mg of intravenous prednisolone equivalents were used daily, and the results in our articles are consistent with other recent literature reporting complicating corticosteroid doses.[31-34]

The fact that the most common complication title in this article is post-COVID-19 high-dose corticosteroid use or vaccination-induced unilateral femoral head avascular necrosis and that a minority of cases require surgical intervention is compatible with the current literature on this subject. Other rare causes still maintain their etiological mysteries.[5-11]

According to SIGN100,[12] most of the articles about avascular necrosis that happened after COVID-19 have evidence levels of 3 or 4. This is because they are mostly case reports, case series, and editorials that were written while the pandemic was still going on. Although the level of evidence is not high, the reason why most of these articles are published in high H-index journals (open access predominantly) may be related to the fact that they are the first articles on this subject and that some high-impact journals facilitate the acceptance of COVID-19-related articles to support increasing scientific sharing on the COVID-19 pandemic. The reason why the majority of trending topic articles included in our study are published in English may be related to the fact that this language is a common scientific language.[35]

According to an updated study we did on articles that were currently popular, avascular necrosis of the femoral head is the most common orthopedic problem that can happen after using high doses of corticosteroids after COVID-19. This is followed less commonly by knee and It has been determined through citation reports and scientific sharing that avascular osteonecrosis occurs in the jaw. In addition, in some cases, avascular necrosis is accompanied by septic arthritis and gastrointestinal bleeding, and rarely, the etiology is reported to be vaccination. To our best knowledge, as a lesson from the COVID-19 pandemic, the high pharmacovigilance of clinicians regarding the use of high-dose corticosteroids is very important in reducing complications and sequelae.

Limitations

Even though the social attention-based AAS was used to try to fix the problems caused by the articles in the study being based on citations, this study still has some of the same problems as bibliometric articles and altmetric analysis that look at trends over time.

Disclosures

Ethics Committee Approval: This research was conducted in accordance with the principles of the Helsinki Declaration. This study did not require approval from an ethics committee because it consisted of a bibliometric and altmetric analysis of previously published studies for which ethics approval had been obtained.

Peer-review: Externally peer-reviewed.

Conflict of Interest: None declared.

References

1. Mehraeen E, Karimi A, Barzegary A, Vahedi F, Afsahi AM, Dadras O, et al. Predictors of mortality in patients with COVID-19-a systematic review. Eur J Integr Med 2020; 40:101226.
2. The Novel Coronavirus Pneumonia Emergency Response Epidemiology Team. The Epidemiological Characteristics of an Outbreak of 2019 Novel Coronavirus Diseases (COVID-19) - China, 2020. China CDC Wkly 2020; 2:113-22. PMID: 34594836
3. Atik OŞ. Corticosteroid-induced avascular necrosis of the femoral head is increased in the treatment of COVID19 pandemic. Jt Dis Relat Surg 2023; 34:757-8.
4. Koc S, Kupeli I. Comparison of high-dose, short-term steroid and low-dose long-term steroid use in ARDS caused by COVID-19: Retrospective cohort study. J Surg Med 2022; 6:360-3.
5. Velchov V, Georgiev P, Tserovski S, Tsenkov T, Alexiev V. Corticosteroid-Associated Avascular Necrosis of the Femoral Head in Patients with Severe COVID-19: A Single-Center Study. Med Sci Monit 2023; 29: e940965.
6. Inneh A, Martinez K, Elizee J, Ganguli M, Turan A. COVID-19-Related Bilateral Avascular Necrosis of the Femoral Head. Cureus 2023; 15: e44034.
7. Hassan AAA, Khalifa AA. Femoral head avascular necrosis in COVID-19 survivors: a systematic review. Rheumatol Int 2023; 43: 1583-95.
8. George G, Lane JM. Osteonecrosis of the Femoral Head. J Am Acad Orthop Surg Glob Res Rev 2022; 6(5):e21.00176.
9. Malinowski K, Skowronek P, Hirschmann M, Kim DW, Henry BM, Ebisz M, et al. Transient spontaneous osteonecrosis of the knee (SONK) shortly after SARS-CoV-2 infection: A report of 2 cases. Adv Clin Exp Med 2022;31:1035-41.
10. Sood A, Nayyar V, Roychoudhury A, Bhalla AS, Mishra D. Post-COVID steroid induced avascular necrosis of the jaw: Emerging challenge in India. Oral Surg Oral Med Oral Pathol Oral Radiol 2023;135:e89-e93.
11. Kashkosh A, Peake CM, Narvani AA, Imam MA. Spontaneous Avascular Necrosis of the Humeral Head Following COVID-19 Vaccination. Arch Bone Jt Surg 2023;11:140-3.
12. SIGN100 A handbook for patient and carer representatives- March 2019. Avaible from https://www.sign.ac.uk/media/1052/sign100.pdf. (Accessed September 29, 2023).
13. The donut and Altmetric Attention Score. Avaible from https://www.altmetric.com/about-us/our-data/donut-and-altmetric-attention-score/ (Accessed September 14, 2023).
14. Dimensions Badges - Dimensions AI.Avaible from https://badges.dimensions.ai/ (Accessed September 14, 2023).
15. Biesiadecki L, Hess B, Schoch-Spana M. Reimagining Preparedness in the Era of COVID-19. Health Secur 2023;21(S1):S1-S7.
16. Lim JT, En WL, Tay AT, Pang D, Chiew CJ, Ong B, et al. Long-term Cardiovascular, Cerebrovascular, and Other Thrombotic Complications in Coronavirus Disease 2019 Survivors: A Retrospective Cohort Study. Clin Infect Dis 2023:ciad469.
17. Olmeda-Gómez C, Perianes-Rodríguez A. "Altmetrics as a research specialty (Dimensions, 2005-2018)". El profesional de la información 2019;28: 1-18.
18. Koprubasi S, Bulut E, Celebi ARC.The relationship between citation-based metrics and Twitter in the area of age related macular degeneration research: Altmetric and bibliometric study.J Clin Med Kaz 2022; 19: 12-22.
19. Ferguson NM, Laydon D, Nedjati-Gilani G, Imai Natsuko, Ainslie K, Baguelin M, et al. Impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand. Imperial College London (16-03-2020).
20. Sightsavers - Our research. Avaible from https://www.sightsavers.org/disability/research/ (Accessed September 29, 2023).
21. Sezer HB, Bohu Y, Hardy A, Lefevre N, Sezer A. Relationship of Altmetric Attention Score, Twitter Performance, and Dimensions Badge Value With Traditional Metrics in Top-Cited Anterior Cruciate Ligament Research Studies. Orthop J Sports Med 2023;11:23259671231166701.
22. Dokur M, Güler Baysoy N, Borku Uysal B, Karadağ M, Demirbilek M. An altmetric study: Social attention based evaluation of top-100 publications about the COVID-19pandemic from notification of the first case to the 6th month. Turk Hij Den Biyol Derg 2021; 78: 411-42.
23. Cheng VC, Wong SC, Chuang VW, So SY, Chen JH, Sridhar S, et al. The role of community-wide wearing of face mask for control of coronavirus disease 2019 (COVID-19) epidemic due to SARS-CoV-2. J Infect 2020 l;81:107-14.
24. Borcak D, Balta M, Bulut E, Ozalp S, Celik Y, Guler T et al. Clinical characterictics and treatments modalities of patients with COVID-19 Infection during the early phase of the epidemic: A single-center from Turkey. Eur J Ther 2022;28: 135-41.
25. Fenta ET, Tiruneh MG, Delie AM, Kidie AA, Ayal BG, Limenh LW, Astatkie BG, Workie NK, Yigzaw ZA, Bogale EK, Anagaw TF. Health literacy and COVID-19 vaccine acceptance

worldwide: A systematic review. SAGE Open Med 2023;11: 20503121231197869.
26. WHO-COVID-19 Treatments/Module-3-Corticosteroid-therapy-and-COVID19,27 May 2020.Avaible from https://www.who.int/emergencies/diseases/novel-coronavirus-2019/treatments (Accessed September 29, 2023).
27. Siddiqi HK, Mehra MR. COVID-19 illness in native and immunosuppressed states: A clinical-therapeutic staging proposal. J Heart Lung Transplant 2020;39:405-407.
28. Koutalos AA, Stefanou N, Malizos KN. Postacute sequelae of SARS-CoV-2 infection. Osteonecrosis must not be overlooked. Int J Infect Dis 2022;121:11-3.
29. Veizi E, Erdoğan Y, Sezgin BS, Karaman Y, Kılıçarslan K, Fırat A. The painful joint after COVID-19 treatment: A study on joint osteonecrosis following COVID-19-related corticosteroid use. Jt Dis Relat Surg 2023;34:75-83.
30. Yang D, Yang SH, Lee JM, Lee JM, Kim J. Effects of socioeconomic status on physical activity and cardiovascular diseases prior to and during the COVID-19 pandemic in the older adults. Front Public Health 2023;11:1241027.
31. Agarwala SR, Vijayvargiya M, Pandey P. Avascular necrosis as a part of 'long COVID-19'. BMJ Case Rep 2021;14: e242101.
32. Annam P, Manda A, Myneni UK, Sahar AN, Prasad N, Sam KK, et al. Corticosteroids induced avascular necrosis of hip, a "long COVID-19" complication: Case report. Ann Med Surg (Lond) 2022; 82: 104753.
33. Shetty GM. Double Trouble-COVID-19 and the Widespread Use of Corticosteroids: Are We Staring at an Osteonecrosis Epidemic? Indian J Orthop. 2021;56:226-36.
34. Dhanasekararaja P, Soundarrajan D, Kumar KS, Pushpa BT, Rajkumar N, Rajasekaran S. Aggressive Presentation and Rapid Progression of Osteonecrosis of the Femoral Head After COVID-19. Indian J Orthop 2022;56:1259-67.
35. Ahmadi A, Allahverdipour H, Valiee S, Pashazadeh F, Ghassab-Abdollahi N, Abdoli F, Matlabi H. COVID-19 stress and coping strategies among older adults: a systematic review of qualitative evidences. BMC Psychol 2023;11:333.