Research Article

Impact of Conventional and Open Access Publications in Orthopaedic Surgery

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ABSTRACT

Introduction: The academic impact of open access publications compared with conventional publications in orthopaedic surgery is not well described. The primary objective of this study was to compare the number of academic citations and social media posts between recent conventional and open access publications in orthopaedic surgery. Secondary objectives of this study were (1) to determine the correlation between academic citations and social media posts and (2) to study the trend of academic citations and social media posts over time.

Methods: An internet-based study was performed on 3,720 articles from five high-impact orthopaedic journals and their associated open access journals from March 2017 to February 2019, including 2,929 conventional and 791 open access journal publications. Academic citations were quantified using Google Scholar and Web of Science, and social media mentions using Twitter. The Mann-Whitney *U* test was used for comparisons of nonparametric data, and the Spearman rank correlation coefficient was calculated for correlations.

Results: The average number of academic citations per article was 10.1 on Google Scholar and 6.0 on Web of Science. The average number of Twitter posts per article was 1.6. Conventional publications had markedly more citations than open access publications on Google Scholar and Web of Science. Open access publications had markedly more Twitter posts, but the effect size was small and unimportant. Academic citations were weakly correlated with social media posts. On average, orthopaedic publications accrue 7.4 citations per year on Google Scholar and 4.6 citations per year on Web of Science.

Discussion: Our findings support a citation advantage to conventional publication. Publications in open access journals are cited less frequently and less rapidly compared with those in conventional journals. The use of social media for orthopaedic research is effectively equivalent between conventional and open access journals and continues to grow.

Level of Evidence: N/A

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Open access publication has emerged as a model to increase readership of original research without the need for subscription. In contrast to conventional, subscription-based journals, open access journals shift the cost of publication from the reader or academic institution to the author or funding agency. Many conventional journals have started companion open access journals in attempts to increase the number and reach of publications.[1-3]

There has been a growth of open access publications in orthopaedic surgery[3-5]; however, the academic impact of open access publications compared with conventional publications in orthopaedic surgery is not well-understood. Theoretically, open access journals offer more widespread and equitable dissemination of original research, by allowing readership to anyone with internet access, without academic affiliation or subscription fee, which may more immediately affect the scientific community. However, the article processing charge may be a deterrent for authors, which may result in the publication of lower impact research in open access journals.[3]

The primary objective of this study was to compare the number of academic citations and social media posts between recent conventional and open access publications in orthopaedic surgery. Secondary objectives of this study were (1) to determine the correlation between academic citations and social media posts among recent orthopaedic publications and (2) to study the trend of academic citations and social media posts over time. Our null hypothesis was that there is no difference in academic citations or social media posts between conventional and open access publications in orthopaedic surgery.

Methods

An internet-based study was performed without human subjects, and therefore, institutional review board approval was deferred. This study comprised all original scientific research articles from five high-impact orthopaedic surgery journals and their respective associated open access journals, published from March 2017 to February 2019 (Table 1). The journals were selected across orthopaedic disciplines and reflected a variety of anatomic locations. The conventional journals included *American Journal of Sports Medicine*, *Journal of Arthroplasty*, *Journal of the American Academy of Orthopaedic Surgeons* (JAAOS)®, *Journal of Bone and Joint Surgery*, *and Journal of Shoulder and Elbow Surgery*, and their respective associated open access journals were *Orthopaedic Journal of Sports Medicine*, *Arthroplasty Today*, *Journal of the American Academy of Orthopaedic Surgeons Global Research & Reviews*, *Journal of Bone and Joint Surgery Open Access*, *and Journal of Shoulder and Elbow Surgery International*. The companion open access journals in our study allow direct submissions or transfers from their parent conventional journal. All original scientific research articles were included in our analysis. Editorials, commentaries, review articles, technique articles, short reports, case reports, conference proceedings, and errata were excluded. Publications in conventional journals published as open access by author choice were excluded. A final sample of 3,720 original full-length scientific research articles, including 428 articles from *Journal of Bone and Joint Surgery*, 62 articles from *Journal of Bone and Joint Surgery Open Access*, 108 articles from JAAOS, 67 articles from *Journal of the American Academy of Orthopaedic Surgeons Global Research & Reviews*, 625 articles from *Journal of Shoulder and Elbow Surgery*, 51 articles from *Journal of Shoulder and Elbow Surgery International*, 1,088 articles from *Journal of Arthroplasty*, 72 articles from *Arthroplasty Today*, 680 articles from *American Journal of Sports Medicine*, and 539 articles from *Orthopaedic Journal of Sports Medicine*, were included for analysis.

For each publication, academic citations were quantified using Google Scholar and Web of Science, both web-based indices of research publications and metadata from multiple databases and across disciplines. Both Google Scholar and Web of Science began indexing in 2004. Web of Science is developed by Thomson Scientific, is updated weekly, and includes 8,700 journals. Google Scholar is developed by Google, is updated monthly on average, and includes all available electronic resources.[7] For each publication, social media mentions were assessed using Twitter, a social networking platform with over 300 million active monthly users.[8] The total number of social media posts on Twitter was determined for each article by searching the article name, which was further subdivided into original tweets and retweets. Furthermore, social media posts were assessed for official tweets, by the publisher, journal, or national organization, and tweets by an author. All data were collected within a 10-day period between April 4, 2020, and April 13, 2020, collectively by all study investigators. Time elapsed since publication ranged from 13 to 37 months in this study.

Descriptive statistics were calculated. One article was not indexed in Google Scholar, and 12 articles were not indexed in Web of Science; statistical analyses were performed on complete data sets only. The Mann-Whitney *U* test and Wilcoxon signed rank sum test were used to

Table 1. Characteristics of Orthopaedic Journals

Conventional Journals			Open Access Journals			
	Date of Inception	Impact Factor[6]		Date of Inception	Date of PubMed Indexing	APC[a]
AJSM	September 1972	4.517	OJSM	June 2013	November 2015	$1,200
JA	January 1986	2.515	AT	March 2015	March 2017	$2,495
JAAOS	September 1993	3.055	JAAOS GRR	March 2017	December 2018	$1,650
JBJS	September 1889	5.163	JBJS OA	October 2016	September 2018	$2,250
JSES	January 1992	2.412	JSES I	March 2017	March 2020	$1,250

APC = article processing charge, AJSM = *American Journal of Sports Medicine*, AT = *Arthroplasty Today*, JA = *Journal of Arthroplasty*, JAAOS = *Journal of the American Academy of Orthopaedic Surgeons*, JBJS = *Journal of Bone and Joint Surgery*, JSES = *Journal of Shoulder and Elbow Surgery*, JAAOS GRR = *Journal of the American Academy of Orthopaedic Surgeons Global Research & Reviews*, JBJS OA = *Journal of Bone and Joint Surgery Open Access*, JSES I = *Journal of Shoulder and Elbow Surgery International*, OJSM = *Orthopaedic Journal of Sports Medicine*

[a]APC is as of June 2020 for original research article submissions for the general public, without consideration of society memberships.

compare unpaired and paired nonparametric data. Correlations were calculated using the Spearman rank correlation coefficient. Significance was defined at $\alpha = 0.05$.

Results

Characteristics of Orthopaedic Publications

The number of academic citations and social media posts was determined for 3,720 orthopaedic publications, including 2,929 publications from conventional journals and 791 publications from open access journals (Table 2). The average number of academic citations per article was 10.1 on Google Scholar and 6.0 on Web of Science. The average number of Twitter posts per article was 1.6, consisting of 0.6 tweets and 1.0 retweets. There were on average 0.1 official tweets and 0.04 author tweets per article. Among the 10 journals in the study, there were on average 2.5 to 15.7 citations on Google Scholar, 1.2 to 9.3 citations on Web of Science, and 0.6 to 3.1 posts of Twitter per article (Table 3).

Conventional Versus Open Access

The number of academic citations and social media posts significantly differed between conventional publications and open access publications (Table 2). Conventional publications had more academic citations than open access publications on average on Google Scholar (11.3 versus 5.7, $P < 0.0001$) and Web of Science (6.8 versus 3.0, $P < 0.0001$). The average number of social media posts per article (including both tweets and retweets) on Twitter was 1.6 for conventional publications compared with 1.7 for open access publications ($P = 0.02$). Although the number of tweets was not significantly different between conventional and open access publications ($P = 0.08$), open access publications generated significantly more retweets ($P < 0.0001$), official tweets ($P < 0.0001$), and author tweets ($P < 0.0001$).

Academic Citation Versus Social Media Posting

Paired comparisons showed that the number of citations on Google Scholar and Web of Science was significantly associated with the number of Twitter posts ($P < 0.0001$ for both). The number of academic citations on Google Scholar was weakly correlated with the number of Twitter posts ($\rho = 0.08$, $P < 0.0001$). Similarly, the number of academic citations on Web of Science was weakly correlated with the number of Twitter posts

Table 2. Academic and Social Media Citations of Conventional and Open Access Orthopaedic Publications

	All Publications			Conventional Publications			Open Access Publications			
	n	Mean (SD)	Median (IQR)	n	Mean (SD)	Median (IQR)	n	Mean (SD)	Median (IQR)	*P*
Google Scholar	3,719	10.1 (14.6)	7 (3-13)	2,928	11.3 (15.9)	8 (4-14)	791	5.7 (6.5)	4 (2-7)	<0.0001
Web of Science	3,708	6.0 (7.4)	4 (2-8)	2,929	6.8 (7.9)	5 (2-9)	779	3.0 (3.8)	2 (1-4)	<0.0001
Twitter posts	3,720	1.6 (6.1)	0 (0-1)	2,929	1.6 (6.5)	0 (0-1)	791	1.7 (4.3)	0 (0-2)	0.02

Table 3. Academic and Social Media Citations of Recent Orthopaedic Publications by Journal

	Google Scholar			Web of Science			Twitter Posts		
	n	Mean (SD)	Median (IQR)	n	Mean (SD)	Median (IQR)	n	Mean (SD)	Median (IQR)
AJSM	680	14.4 (14.7)	10 (5-18)	680	9.3 (9.4)	6 (3-12)	680	3.1 (9.5)	0 (0-2)
OJSM	539	6.6 (6.8)	5 (2-8)	539	3.5 (4.0)	2 (1-5)	539	2.0 (5.0)	0 (0-2)
JA	1,088	10.1 (10.5)	7 (3-13)	1,088	6.2 (7.1)	4 (2-8)	1,088	0.6 (1.5)	0 (0-0)
AT	72	6.8 (8.0)	4 (2-7)	60	3.1 (4.4)	2 (1-4)	72	0.9 (2.1)	0 (0-1)
JAAOS	108	5.5 (5.6)	4 (1-8)	108	3.1 (3.8)	2 (1-4)	108	1.6 (3.0)	1 (0-2)
JAAOS GRR	67	2.6 (4.3)	1 (0-3)	67	1.2 (2.0)	1 (0-1)	67	0.9 (2.5)	0 (0-0)
JBJS	427	15.7 (30.9)	9 (4-18)	428	8.3 (9.5)	6 (2-11)	428	2.4 (9.3)	0 (0-2)
JBJS OA	62	3.7 (3.4)	3 (1-6)	62	1.8 (2.4)	1 (0-3)	62	1.1 (2.1)	0 (0-2)
JSES	625	8.2 (7.7)	6 (3-11)	625	4.7 (5.0)	3 (1-6)	625	1.2 (5.3)	0 (0-1)
JSES I	51	2.5 (2.1)	2 (1-3)	51	1.3 (1.4)	1 (0-2)	51	1.1 (2.1)	0 (0-1)

AJSM = *American Journal of Sports Medicine*, AT = *Arthroplasty Today*, JA = *Journal of Arthroplasty*, JAAOS = *Journal of the American Academy of Orthopaedic Surgeons*, JBJS = *Journal of Bone and Joint Surgery*, JSES = *Journal of Shoulder and Elbow Surgery*, JAAOS GRR = *Journal of the American Academy of Orthopaedic Surgeons Global Research & Reviews*, JBJS OA = *Journal of Bone and Joint Surgery Open Access*, JSES I = *Journal of Shoulder and Elbow Surgery International*, OJSM = *Orthopaedic Journal of Sports Medicine*

(ρ = 0.07, P = 0.0006). As expected, the number of academic citations on Google Scholar and Web of Science was strongly correlated (ρ = 0.91, $P < 0.0001$).

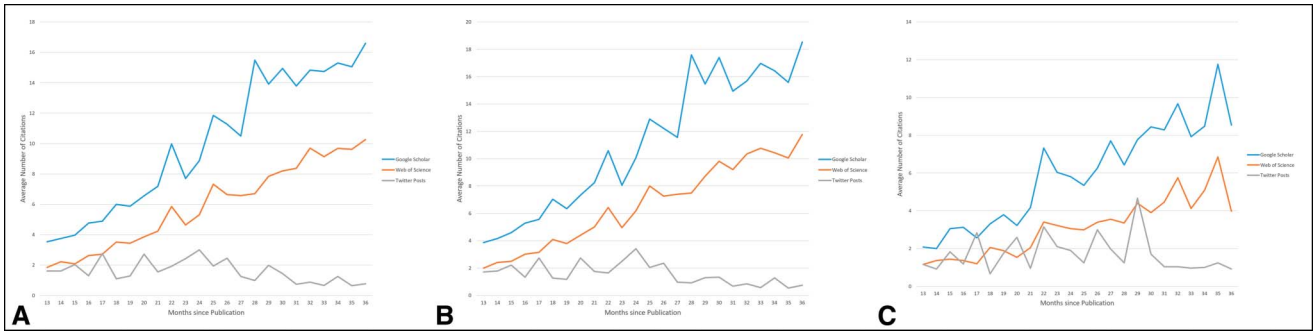
Temporal Effects on Citation

Earlier publication was moderately correlated with a greater number of citations on Google Scholar (ρ = 0.44, $P < 0.0001$) and Web of Science (ρ = 0.42, $P < 0.0001$). A linear increase in academic citations for orthopaedic publications could be seen up to the time of data collection for both conventional and open access publications (Figure 1). Academic citations of orthopaedic publications accrued at a rate of 7.4 per year on Google Scholar and 4.6 per year on Web of Science. The yearly rate of growth of academic citations on Google Scholar ranged from 5.0 to 13.4 in conventional journals and 0 to 18.0 for open access journals. The yearly rate of growth of academic citations on Web of Science ranged from 2.6 to 7.7 in conventional journals and 0 to 8.0 for open access journals. Conversely, later publication was weakly correlated with a greater number of social media posts (ρ = 0.10, $P < 0.0001$; Figure 1). Twitter posts per publication are growing at a rate of 0.6 per year.

Discussion

Despite the advent and rise of open access journals in orthopaedic surgery,[3,5] the relative scientific impact of these open access journals compared with conventional subscription-based journals has not been well-described. There are clear advantages to open access publication. Open access journals provide more rapid dissemination

Figure 1



Line plots illustrating the average number of citations per article by months since publication for (**A**) all publications, (**B**) conventional publications, and (**C**) open access publications.

of research findings and more equitable worldwide access to readers who may otherwise not be able to afford subscription costs.[3] In cases of government-funded research, open access journals make publicly funded research freely available to the public.[2] Despite its advantages, there is a concern that the cost of open access publication would be a deterrent for authors such that open access journals would attract lower quality research with ultimately lower scientific impact.[2,3] Furthermore, the increasing mainstream adoption of legitimate open access journals has been accompanied by a rise in the number of predatory journals. Predatory journals are characterized by the Beall criteria[9] and describe journals from counterfeit publishers that exploit the open access model to extract monetary gains from authors. These journals frequently aggressively solicit submissions, falsify editorial boards, and provide inadequate peer review.[10] In our study of 3,720 recent publications in the orthopaedic literature, we have demonstrated that publications in conventional journals are markedly more cited than those in open access journals. Open access publications have slightly more posts on social media compared with conventional publications, but the effect size is small and likely not practically important.

The effect of open access publication on academic impact and citation metrics remains controversial, in both medicine, in general,[11-13] and orthopaedics, in particular.[3,5] Although some previous research shows a citation advantage to open access publication,[11,13] others show no difference,[5,12] and still others show an association with lower impact output from open access journals.[3] Davis et al performed a randomized controlled trial in which scientific articles were randomly assigned to subscription access or open access in the same set of journals. After controlling for quality of research, Davis et al did not find a citation advantage to open access publication. Our findings do not support a citation advantage to open access publication in orthopaedic surgery; on the contrary, open access orthopaedic journal publications are less frequently cited than their conventional counterparts. One plausible explanation for our finding is that, in contrast to other specialties, most orthopaedic research is not extrinsically funded.[2] Consequently, the cost of publication may preclude or disincentivize orthopaedic researchers from open access journals, thus selecting for lower impact research publications. The direct effects of cost of publication on impact and quality are beyond the scope of this study. In addition, there may have been selection bias in the articles published in companion open access journals, insofar as the manuscript may have been prescreened by the parent conventional journals. Finally, there may still be a component of stigma around publishing in open access journals that affect where authors choose to publish.

Academic citation is a well-studied metric of research impact and productivity and has been correlated with academic rank[14-16] and research funding.[17] However, academic citations have disadvantages, and alternative metrics of research productivity, such as social media mentions, have recently emerged.[18,19] Social media posts have been argued as a more immediate measure of research impact, whereas academic citations often take years to accrue. Moreover, social media posts capture the impact of research on readers who do not publish or cite and thus may be a more complete metric of the societal impact of a scholarly work.[20-23] The validity of social media posts as metrics of scholarly impact has been supported by studies that demonstrate its correlation with conventional citations, journal impact factor, risk-of-bias score, and author productivity.[20,21] Moreover, social media posts are shown to accrue more immediately after publication compared with conventional citations.[20] In our study, we have demonstrated that social media posts are weakly, but markedly, correlated with academic citations. There is a notable tendency for academically cited articles to be mentioned on social media. Our results are in accordance with the previous literature,[20,21] and although the adoption of social media as a vehicle of research dissemination continues to grow, the strength of correlation between social media posts and academic citations has not increased. The observed weakness of correlation may be due to inherent teleological differences between academic citation and social media posts. The purpose of some social media posts may be to simply raise awareness or generate online discussion, in contrast to academic citations.

To the knowledge of the authors, the temporal relationship of recent orthopaedic publication and academic citation has not been studied. Since citation is correlated with metrics of scholarly impact and academic promotion,[14-16] the rate at which novel publications in the orthopaedic literature are cited is of interest. We have demonstrated that, on average, orthopaedic publications in high-impact journals accrue 7.4 citations per year on Google Scholar and 4.6 citations per year on Web of Science, although there is variability based on journals. Interestingly, later publication date is correlated with a higher number of Twitter posts, which is likely reflective of the increasing adoption of this social media platform for research dissemination. The use of Twitter for the average orthopaedic publication is growing at a rate of

0.6 posts per year. The variability of citations between Web of Science and Google Scholar is well-described. Web of Science is more stringent and includes only published articles, not early online articles, whereas Google Scholar includes all electronically available resources and is thus more prone to duplicate references.[7]

There are limitations to this study. First, the study focused on research publications from March 2017 to February 2019. We chose this 2-year study period to assess current trends in the orthopaedic literature, included newly established open access journals, and allowed at least 1 year since publication for citations to accrue. There are inherent limitations to the chosen study period. The mainstream acceptance of open access journals in orthopaedic surgery is relatively recent, and many companion open access journals in this study were in their nascency (Table 1). It is plausible that the impact and citation of open access journals would increase as these nascent journals age and gain indexing. Moreover, the impact of open access journals may increase as acceptance and adoption of the open access model grows. For all these reasons, although we believe our study accurately captures the current bibliometric landscape, these findings may differ in the future. Second, five high-impact orthopaedic surgery journals and their associated open access journals were studied. Although these journals are not exhaustive of the orthopaedic literature, 3,720 publications were included, which we believe is an accurate reflection of the current orthopaedic literature. Third, whether articles were published in conventional journals or open access journals is subject to selection bias. Authors may have preferentially submitted more impactful articles to conventional journals to avoid the article processing charge; alternatively, some articles may have been initially declined by a conventional journal and subsequently transferred to an open access journal. Although we were unable to control for the quality of the research, we believe we have captured the true-to-life bibliometric profiles of five high-impact orthopaedic journals and their associated open access journals. Fourth, there are aspects of journal readership, promotion, and distributions that were not addressed in this study. The size of the readership of a journal and how actively a journal promotes publications on social media may influence bibliometric outcomes. Many open access journals are online only, whereas conventional journals are generally both online and in-print. Mode of distribution may affect publication impact, and this was not controlled for in our study. Fifth, conventional and open access publications may have difference impacts in various geographical locations, depending on access to subscription-based journals. This was not addressed by our study. Finally, Twitter was chosen as our metric of social media research impact, but it is one of many social media platforms on which research is shared. Twitter was chosen as the measure of social media activity in this study because it has recently been shown to be the most prevalently used online platform for musculoskeletal research, accounting for 82% of online mentions, with approximately six times the social media mentions of Facebook, the second most used platform.[20]

The role of open access journals is evolving in the field of orthopaedic surgery, and the impact of open access publications in orthopaedic surgery has not been well-described. Our analysis of a large number of recent publications in orthopaedic surgery does not support a citation advantage to open access publication. Publications in open access journals are cited less frequently and less rapidly compared with those in conventional journals. Social media posts are weakly correlated with the academic citation of orthopaedic research, and the use of social media for the dissemination of orthopaedic research continues to grow.

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