

## Bibliometric Analysis



# Ultrasound Imaging, Guidance, and Treatment for Shoulder-related Pain Syndrome: A Bibliometric Analysis

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**Background:** Ultrasound imaging is shown to be superior to other imaging tools for the evaluation of shoulder disorders in a primary care settings. In addition to its diagnostic utility, ultrasound diathermy is useful as a deep heat modality for the management of shoulder pain.

**Objective and Study Design:** In this study, we analyzed the bibliometric data of publications that have focused on ultrasound imaging/therapy for shoulder-related pain syndrome.

**Methods:** We searched the Web of Science (WoS) database for articles published between January 1, 1976, and June 24, 2022. The CiteSpace Version 6.1R2 software was used to analyze publication output, authoritative journals/countries/institutions/authors, keywords, references, and citations.

**Results:** We analyzed 1185 articles in this study and observed a significant trend of an increase in publications per year ( $\beta$  coefficient 1.8165,  $R^2 = 0.7519$ ,  $P < 0.001$ ). The maximum number of relevant citations was identified in 2009, and these declined in subsequent years. The *Journal of Ultrasound in Medicine*, the United States of America, and the League of European Research Universities were identified as the journal, country, and institution with the highest number of publications, respectively. Keyword analysis revealed that “ultrasonography” showed the strongest citation bursts, followed by “arthroscopic findings” and “painful shoulders.”

**Limitations:** We only analyzed publications indexed in the WoS because most indicators required for bibliometric analysis can be efficiently extracted from its website.

**Conclusion:** This study highlights a significant trend of an increase in the number of publications focused on ultrasound imaging for shoulder-related pain syndrome. Ultrasound was shown to be a highly popular imaging modality among health care practitioners for the evaluation of shoulder disorders. Randomized controlled trials and state-of-the-art reviews are warranted to boost the citation count and conclusively establish the role of ultrasound applications in patients with shoulder pain syndrome.

**Key words:** Bibliometric, imaging, pain, shoulder, ultrasonography

**Protocol Registration:** The study protocol has been registered on Inplasy.com (INPLASY202270016)

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**S**houlder pain is one of the most prevalent musculoskeletal disorders, with a lifetime prevalence of up to 66.7% in the general population (1). Several imaging modalities, including plain radiography, computed tomography, magnetic resonance imaging (MRI), and ultrasound (US), are used for the evaluation of shoulder pathologies. Owing to high spatial resolution and lack of radiation exposure (2), US is shown to score over other imaging tools for the evaluation of shoulder disorders in primary care settings. A recent network meta-analysis reported that the accuracy of high-frequency US technology for the diagnosis of rotator cuff tears was comparable to that of MRI (3). Another advantage of US is its ability to delineate nerves, such as the suprascapular (4) and axillary (5) nerves that innervate the shoulder joint, which facilitates accurate diagnosis and prompt interventions for peripheral nerve entrapment (6). Notably, sonoelastography enables noninvasive measurements of the mechanical properties of tissues (7) and is commonly used for the evaluation of rotator cuff tendon elasticity, as well as post-injection changes in tendons (8). In addition to its diagnostic utility, US diathermy is useful as a deep heat modality for the management of shoulder pain (9). Owing to high cost-effectiveness and accessibility, US is widely preferred not only in clinical settings but also for research purposes. Numerous published studies and reviews (10,11) have discussed the role of US in shoulder disorders; however, no study has performed bibliometric analysis to gain a better understanding of the trends in the literature.

Bibliometric analysis (12) is a contemporary research tool used in information science to analyze the value and effects of scientific literature designated for a certain topic. This methodology facilitates the identification of impactful articles and factors associated with publication metrics (dominant authors, contributory countries, and core journals). Furthermore, utilization of data mining techniques empowers the visual constitution of the collaborative network from researchers and institutes that contribute in a specific domain (13). Several recent studies have reported bibliometric analysis of post-stroke pain (14), geriatric populations (15), and inflammation (16). Considering the popularity of US applications in musculoskeletal medicine, bibliometric analysis dedicated to the use of this modality in patients with shoulder disorders will potentially guide researchers in the identification of unexplored categories and also provide a direction for future research. In this study, we analyzed the bibliometric data of publi-

cations that have focused on US imaging/therapy for shoulder-related pain syndrome.

## METHODS

### Source and Search Strategy

We searched the Web of Science (WoS) database from the earliest available record (January 1, 1976) until June 24, 2022. We used the following search algorithm: "ultrasound" or "ultrasonic" or "ultrasonography" or "ultrasonographic" or "sonoelastography" or "sonography" or "sonographic" or "US" and "shoulder" or "shoulders" or "shoulder pain" or "painful shoulder" or "impingement syndrome" or "adhesive capsulitis" or "calcifying tendinitis" or "calcific tendinitis" or "Hill-Sachs lesion" or "quadrilateral space syndrome" or "os acromiale" or "subcoracoid impingement" or "rotator cuff" or "rotator interval" or "rotator cable" or "biceps" or "bicipital groove" or "subscapularis" or "supraspinatus" or "infraspinatus" or "teres minor" or "clavicle" or "coracoid" or "acromioclavicular joint" or "acromiohumeral distance" or "coracoacromial ligament" or "coracohumeral ligament" or "glenohumeral joint" or "glenoid labrum" or "subacromial" or "suprascapular nerve" or "suprascapular notch" or "scapular" or "axillary nerve" or "posterior circumflex humeral artery." All articles with titles that fulfilled the aforementioned search criteria were screened for eligibility. The study protocol was registered on InPlasy.com (INPLASY202270016).

### Inclusion and Exclusion Criteria

We included articles, reviews, and book chapters that described US imaging, guidance, and therapy for the evaluation and management of shoulder and associated musculoskeletal disorders. Clinical, cadaveric, and basic research were considered within the scope of this bibliometric analysis. Meeting abstracts, letters, editorial materials, proceedings papers, corrections, bibliographic items, animal studies irrelevant to the human shoulder joint, as well as studies that described other imaging modalities or focused on other body parts were excluded.

### Data Retrieval and Classification

All data (author, year, title, journal, volume, issue, page, article type, abstract, keywords, references, and citations) were exported from the WoS database. The first and second authors independently scrutinized the retrieved information to determine the eligibility of these articles for subsequent analysis. Disagreements

between reviewers were resolved by the corresponding author or through consensus-based discussion. The EndNote reference management software (EndNote X9, Bld 7072, Thomson Research Soft, Stanford) was used to identify duplicate publications.

## Statistical Analysis

Most outcomes in the present study are expressed using descriptive statistics (numbers and percentages). Outcomes included annual publication output, journal/country/institution/author distribution, subjective WoS categories, citation bursts (and their keywords), and publications with high citation numbers. Linear regression analysis performed using the Microsoft Excel 2019 software was used to analyze trends in annual publications over time. The CiteSpace 6.1 R2 package (a widely used scientometric analysis tool) was used to generate a co-citation network map, which demonstrated emerging trends, benchmark publications, and clusters of citation bursts (17,18). A  $P$  value  $< 0.05$  was considered statistically significant.

## RESULTS

### Publication Output

Following an initial database search, we identified 1762 publications; 577 articles (duplicates, non-eligible article types, or articles irrelevant to the search topic) were discarded. Fig. 1 illustrates the

literature search strategy. The final analysis included 1185 articles published between January 1, 1976, and June 24, 2022, of which 146 were case reports (with fewer than 3 participants), 929 were original research articles, and 110 were review papers (73 narrative and 37 systematic reviews and meta-analyses). Overall, 853 publications reported diagnostic US, 288 reported US-guided interventions and 44 reported therapeutic US.

We observed an annual increase in the number of publications with a significantly positive trend ( $\beta$  coefficient 1.8165,  $R^2 = 0.7519$ ,  $P < 0.001$ ) (Fig. 2A). Publications from 2022 were not subjected to regression analysis because the last date of the literature search (June 24, 2022) was in mid-2022. The highest number of publications was identified in 2021. Although linear regression analysis showed a trend of increasing citations per year ( $\beta$  coefficient 21.589,  $R^2 = 0.4462$ ,  $P < 0.001$ ) (Fig. 2B), we observed a gradual decline in this trend after 2009 (the year in which the highest number of citations were identified) (Fig. 3A).

### Authoritative Journals and Subjective Categories of the Web of Science Database

The included publications ( $n = 1185$ ) were distributed across 362 academic journals; Table 1 shows the journals with the highest number of publications. The *Journal of Ultrasound in Medicine* contributed to the highest number of publications ( $n = 47$ ), followed by

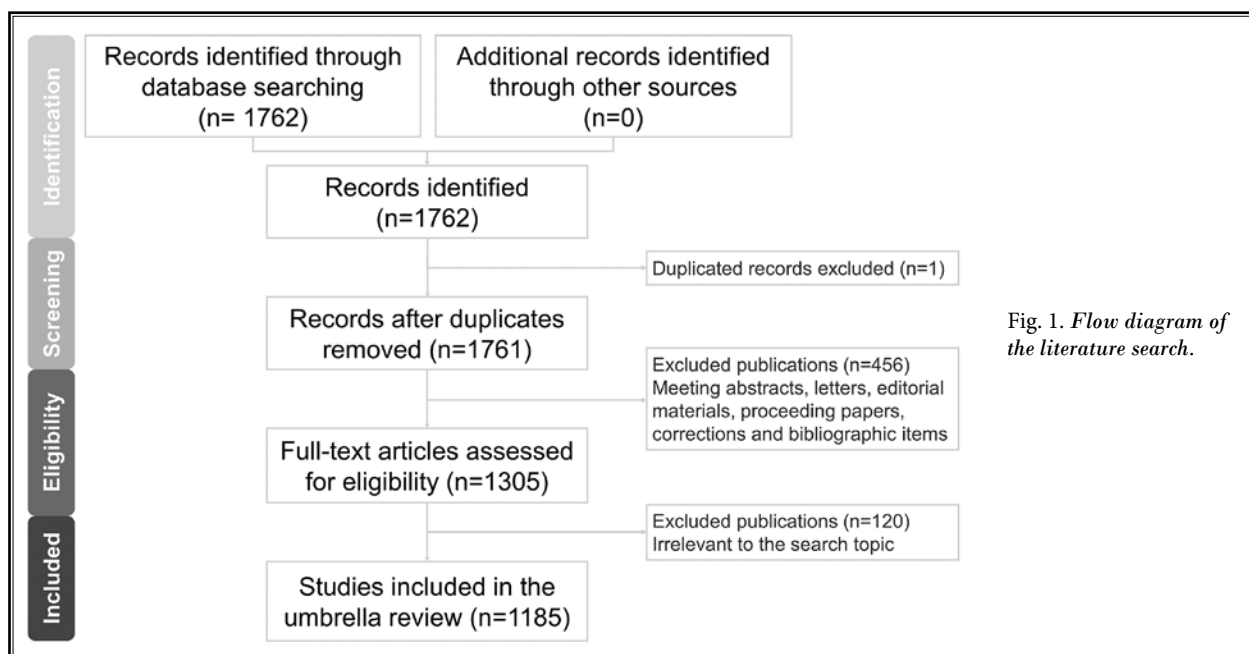
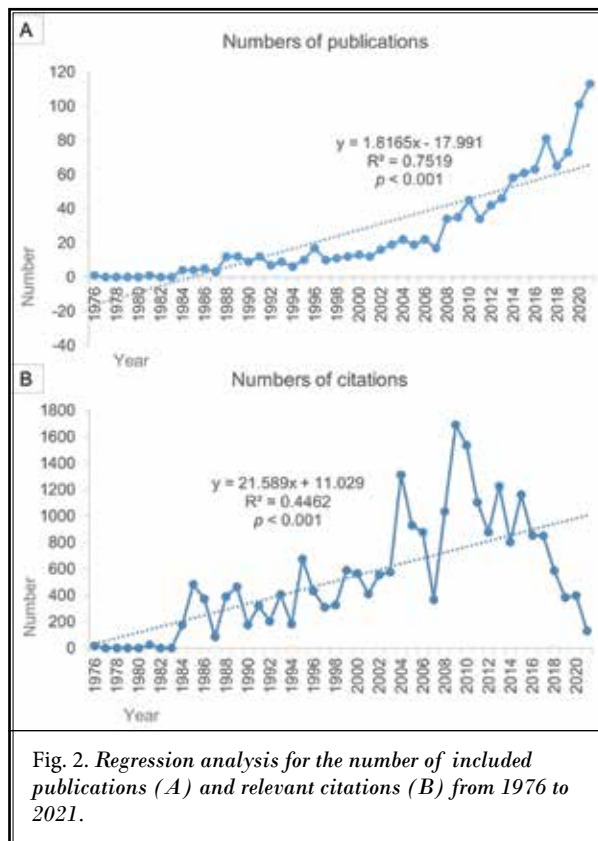


Fig. 1. Flow diagram of the literature search.



the *Journal of Shoulder and Elbow Surgery* ( $n = 44$ ), and the *American Journal of Roentgenology* ( $n = 30$ ), which also had the highest total ( $n = 1274$ ) and mean ( $n = 42.47$ ) number of citations per paper (Fig. 3B). Fig. 4 shows the dual-map overlay of the citing and cited journals. The citing journals that included the aforementioned 1185 publications were mainly from the "medicine, medical, clinical" and "neurology, sports, ophthalmology" domains, whereas the cited journals were primarily from the domains of "health, nursing, medicine," "dermatology, dentistry, surgery," and "sports, rehabilitation, sports."

The included publications ( $n = 1185$ ) were allotted to 52 (subjective) categories in the WoS; Fig. 5A shows these categories with leading publication numbers. The largest number of publications belonged to the field of radiology/nuclear medicine/medical imaging ( $n = 370$ ), followed by orthopedics ( $n = 293$ ), and sports medicine ( $n = 204$ ). The highest number of citations was also from radiology/nuclear medicine/medical imaging ( $n = 9476$ ), whereas the highest number of citations per article ( $n = 26.61$ ) was from the domain of orthopedics.

### Authoritative Countries, Institutions, and Authors

Fig. 5B shows the leading countries based on the number of publications. The highest number of publications was from the United States of America ( $n = 271$ ), followed by South Korea ( $n = 91$ ) and Italy ( $n = 81$ ). The United States of America also had the highest number of citations ( $n = 4367$ ) and citations per paper ( $n = 16.11$ ).

Figure 5C shows the leading institutions with regard to the number of publications. The League of European Research Universities contributed to the highest number of publications ( $n = 54$ ), followed by National Taiwan University ( $n = 30$ ) and Washington University in St. Louis ( $n = 25$ ). The highest number of citations ( $n = 1376$ ) and citations per paper ( $n = 55.04$ ) were also submitted by Washington University in St. Louis. Table 2 shows the top authors with the highest number of included publications, authors with the maximum number of co-cited publications, and those with the highest number of co-cited references.

### Keywords

Fig. 6 shows the 25 leading keywords with the top citation bursts between January 1, 1976, and June 24, 2022. The first 2 words with strong citation bursts were "US" and "instability," and these were identified in 1991. Among the 25 top keywords, "sonography" showed the strongest citation bursts (9.89), followed by "arthroscopic findings" (9.61), and "painful shoulders" (7.48).

### References

Reference co-citation analysis identified 23 clusters (#0-22); Fig. 7 shows the timeline view of these clusters. Co-citation refers to the frequency with which 2 articles are cited together by other publications. The largest cluster, which was categorized as "#2 anthropology," included 45 papers. The most relevant citer to the cluster was "ultrasound of the shoulder and elbow" (19). The second largest cluster category labeled "#0 radiology and nuclear medicine" included 44 papers. The most pertinent citer to the cluster was "rotator cuff tear: clinical-experience with sonographic detection" (20).

### Most Frequently Cited Articles

Table 3 shows the most frequently cited articles. The most-cited publication ( $n = 366$ ) titled "Detection and quantification of rotator cuff tears-comparison of ultrasonographic, magnetic resonance imaging, and

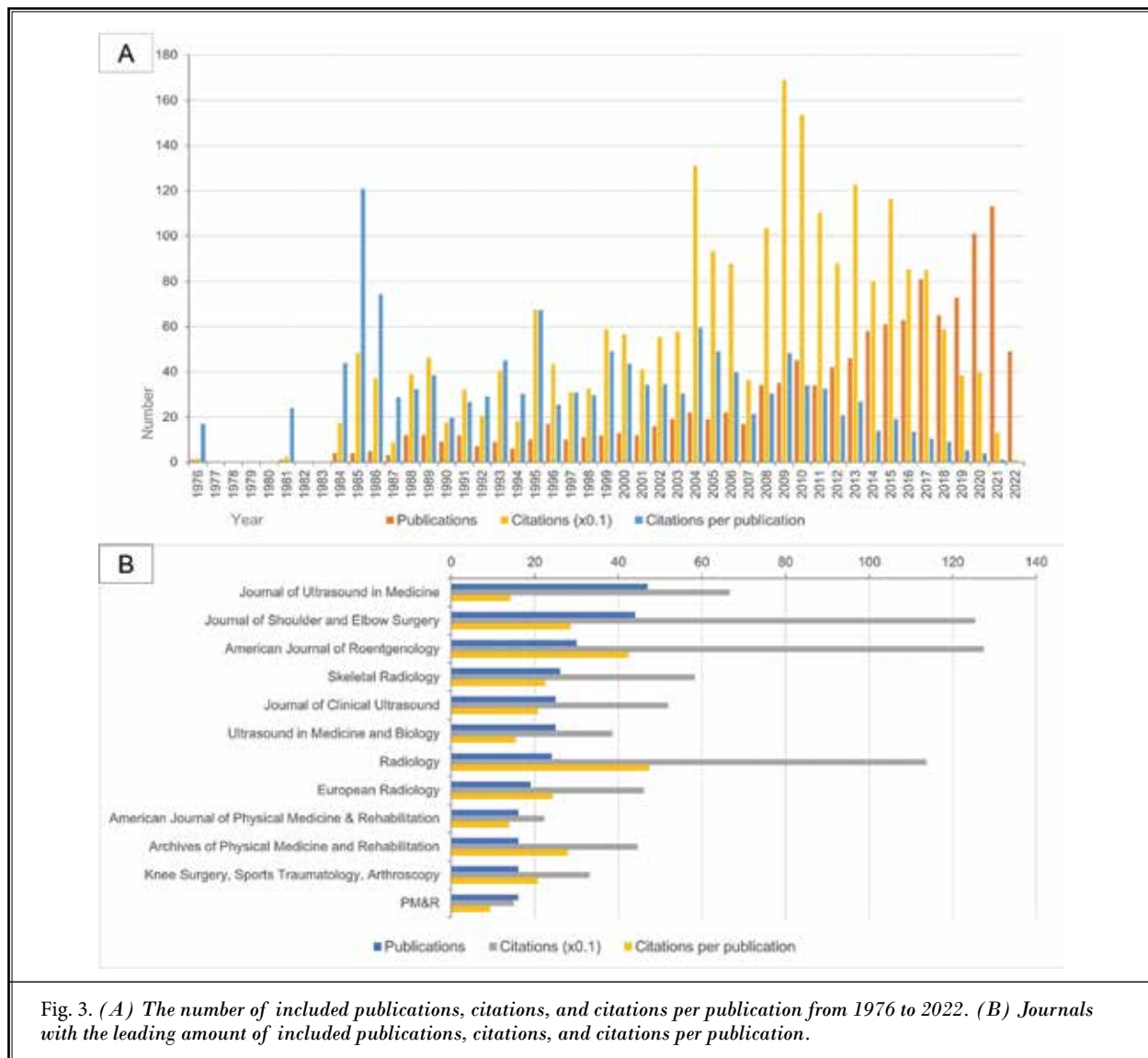


Fig. 3. (A) The number of included publications, citations, and citations per publication from 1976 to 2022. (B) Journals with the leading amount of included publications, citations, and citations per publication.

arthroscopic findings in seventy-one consecutive cases" (21) was authored by Teefey et al and was published by The Journal of Bone & Joint Surgery (American Volume) in 2004.

## DISCUSSION

To our knowledge, this bibliometric analysis is the first study to analyze publications that have focused on the use of US for shoulder-related pain disorders. With regard to publication output, the number of relevant publications showed a steady increase annually; this trend indicates the usefulness of US as an imaging modality and as a valuable tool to guide interventions

for the management of shoulder pain. Additionally, this trend highlights the increasing clinical application of US globally. Notably, the number of citations from the publications included in this study was the highest in 2009, followed by a gradual decline, which may indicate that diagnostic and/or therapeutic US is a well-accepted modality in cases of shoulder disorders, whereas citations were less needed when referring to this modality in the literature. Our findings emphasize that advances in US technology or shoulder sonography are warranted for studies published after 2009.

With regard to authoritative journals, most articles were identified in the *Journal of Ultrasound in Medi-*



Table 1. Journals with the leading number of included publications, citations, and citations of publications.

Journals	Publications	Citations	Citations per publication	Categories of Web of Science	Quartile	H-index
Journal of Ultrasound in Medicine	47	666	14.17	Acoustics; Radiology, nuclear medicine & medical imaging	Q2; Q3	15
Journal of Shoulder and Elbow Surgery	44	1254	28.50	Orthopedics; Sport sciences; Surgery	Q2; Q2; Q2	23
American Journal of Roentgenology	30	1274	42.47	Radiology, nuclear medicine & medical imaging	Q1	22
Skeletal Radiology	26	583	22.42	Orthopedics; Radiology, nuclear medicine & medical imaging	Q3; Q3	14
Journal of Clinical Ultrasound	25	519	20.76	Radiology, nuclear medicine & medical imaging; Acoustics	Q4; Q4	15
Ultrasound in Medicine and Biology	25	386	15.44	Radiology, nuclear medicine & medical imaging; Acoustics	Q1; Q2	13
Radiology	24	1137	47.38	Radiology, nuclear medicine & medical imaging	Q1	24
European Radiology	19	461	24.26	Radiology, nuclear medicine & medical imaging	Q1	10
American Journal of Physical Medicine & Rehabilitation	16	222	13.88	Rehabilitation; Sport sciences	Q2; Q2	7
Archives of Physical Medicine and Rehabilitation	16	446	27.88	Rehabilitation; Sport sciences	Q1; Q2	11
Knee Surgery, Sports Traumatology, Arthroscopy	16	331	20.69	Orthopedics; Surgery; Sport sciences	Q1; Q1; Q1	11
PM&R	16	149	9.31	Rehabilitation; Sport sciences	Q2; Q3	8

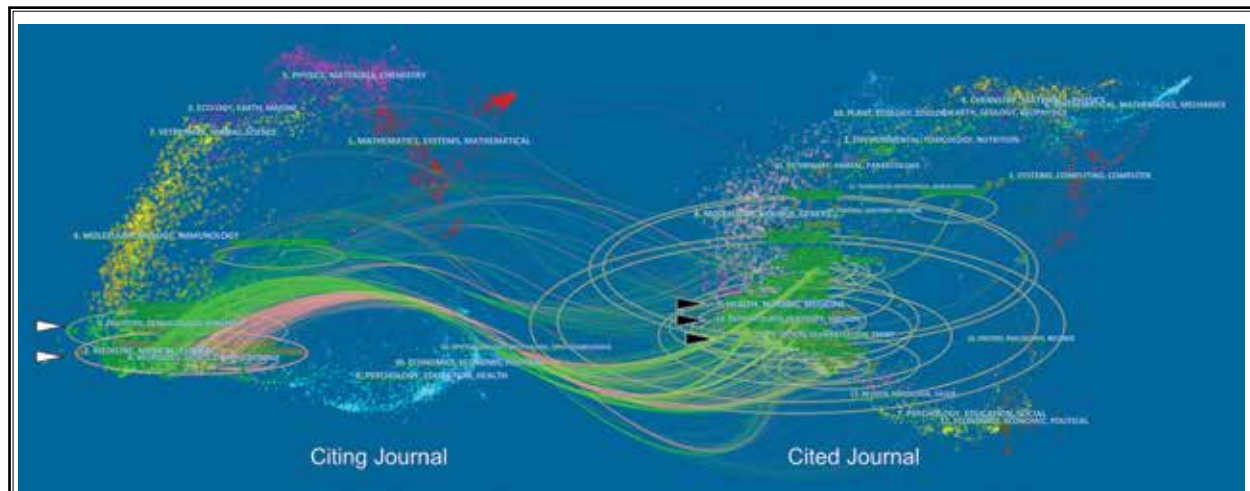


Fig. 4. The dual map overlays of the citing and cited journals. The citing journals of the included publications were mainly from the fields labeled by the white arrowheads (“medicine, medical, clinical” and “neurology, sports, ophthalmology”), whereas the cited journals were mostly within the fields labeled by the black arrowheads (“health, nursing, medicine”, “dermatology, dentistry, surgery” and “sports, rehabilitation, sports”).

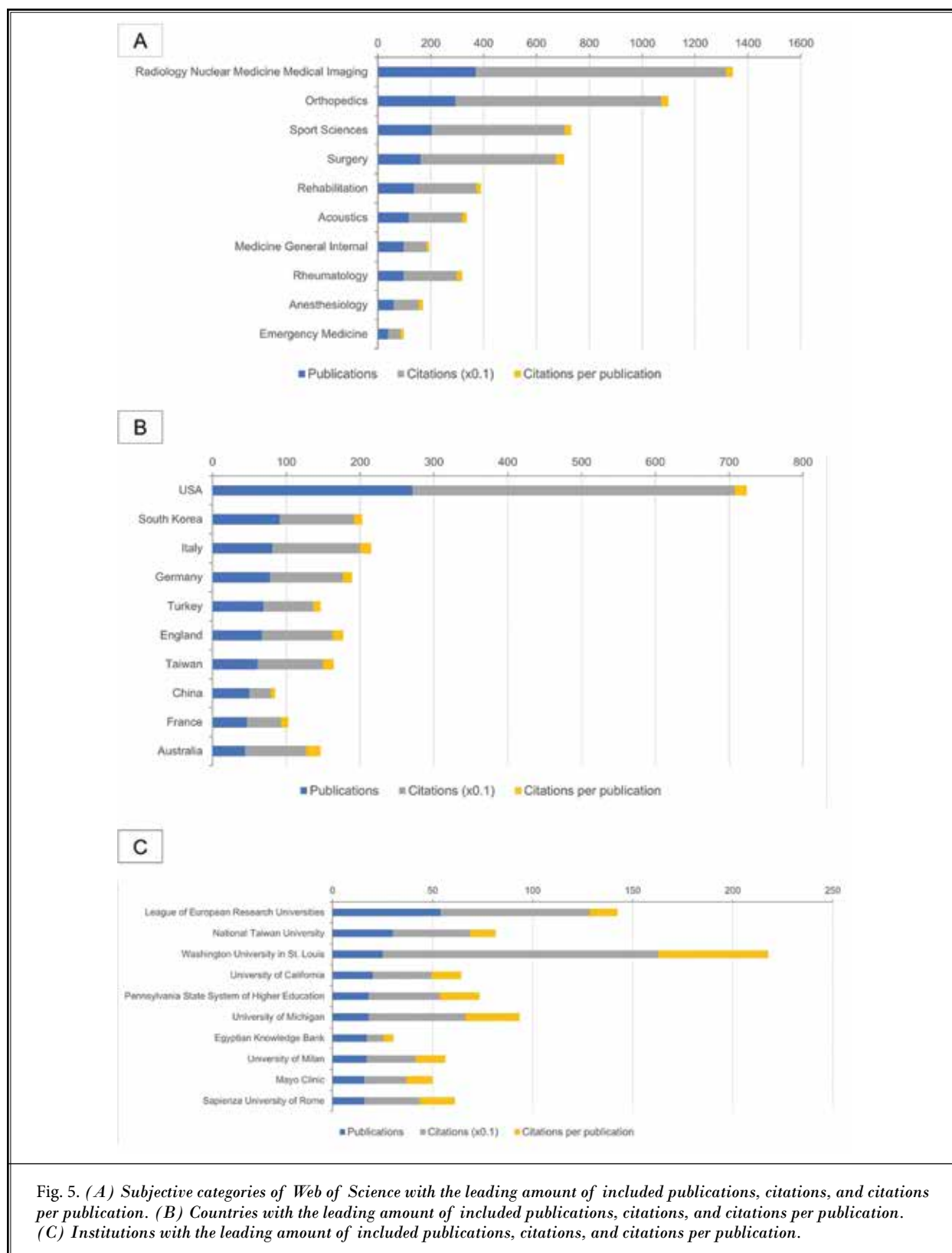


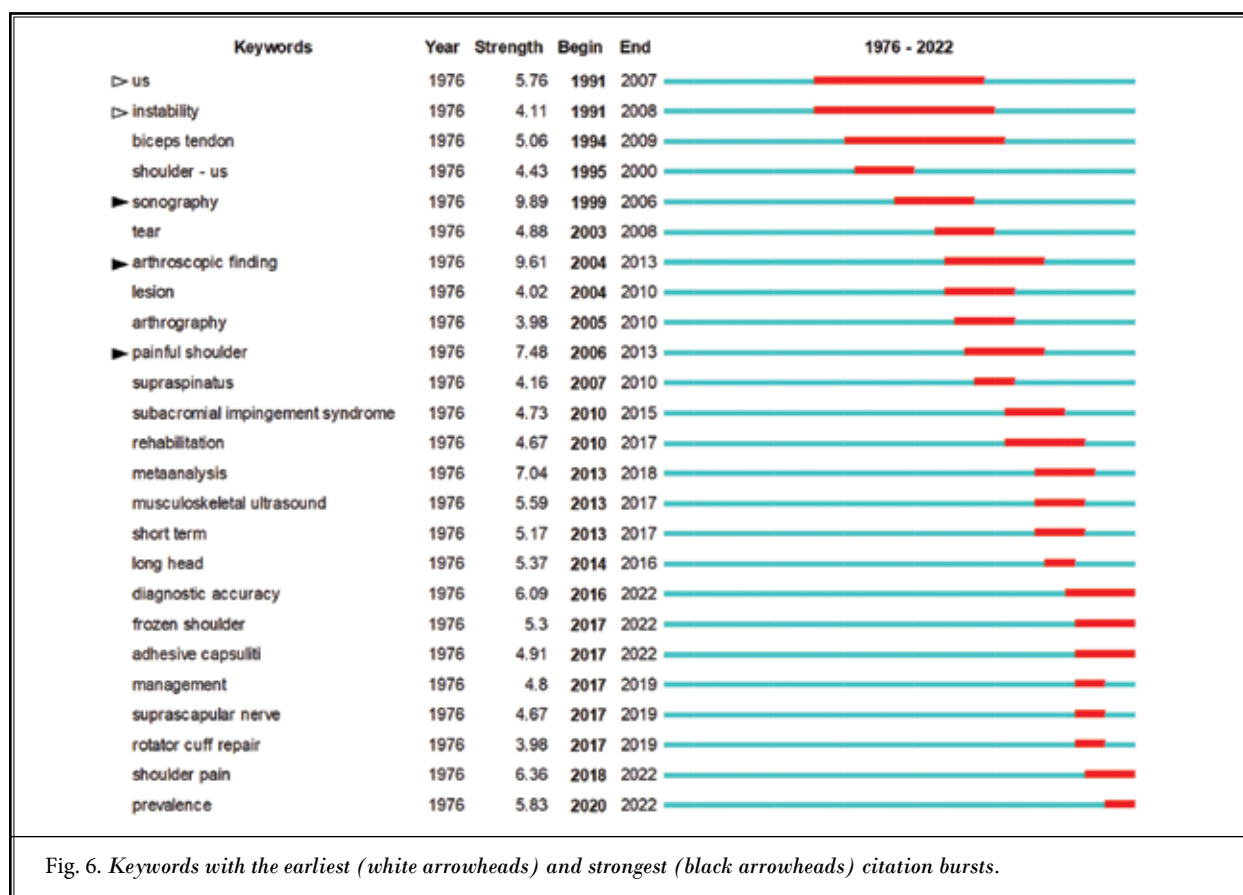
Table 2. Top authors with the leading number of included publications, authors whose publications were co-cited most, and references that were co-cited the most.

Authors with the leading number of included publications		Authors whose publications were co-cited the most		References that were co-cited the most	
Author	Publications	Co-cited author	Cited times	Co-cited reference	Cited times
Ke-Vin Chang	20	William D. Middleton	201	Teefey SA, Hasan SA, Middleton WD, Patel M, Wright RW, Yamaguchi K. Ultrasonography of the rotator cuff. A comparison of ultrasonographic and arthroscopic findings in one hundred consecutive cases. <i>J Bone Joint Surg Am.</i> 2000;82(4):498-504.	31
Ronald S. Adler	19	Sharlene A. Teefey	192	Teefey SA, Rubin DA, Middleton WD, Hildebolt CF, Leibold RA, Yamaguchi K. Detection and quantification of rotator cuff tears. Comparison of ultrasonographic, magnetic resonance imaging, and arthroscopic findings in seventy-one consecutive cases. <i>J Bone Joint Surg Am.</i> 2004;86(4):708-716.	25
Luca Maria Sconfienza	19	Pekka U. Farin	148	de Jesus JO, Parker L, Frangos AJ, Nazarian LN. Accuracy of MRI, MR arthrography, and ultrasound in the diagnosis of rotator cuff tears: a meta-analysis. <i>AJR Am J Roentgenol.</i> 2009;192(6):1701-1707.	23
William D. Middleton	17	Charles S. Neer II	124	Roy JS, Braën C, Leblond J, et al. Diagnostic accuracy of ultrasonography, MRI and MR arthrography in the characterisation of rotator cuff disorders: a systematic review and meta-analysis. <i>Br J Sports Med.</i> 2015;49(20):1316-1328.	22
Ken Yamaguchi	14	Laurence A. Mack	121	Mack LA, Matsen FA 3rd, Kilcoyne RE, Davies PK, Sickler ME. US evaluation of the rotator cuff. <i>Radiology.</i> 1985;157(1):205-209.	19
Annamaria Iagnocco	13	Jeffrey A. Crass	119	Middleton WD, Edelstein G, Reinus WR, Melson GL, Totty WG, Murphy WA. Sonographic detection of rotator cuff tears. <i>AJR Am J Roentgenol.</i> 1985;144(2):349-353.	19
Levent Özçakar	13	Matthieu J. C. M. Rutten	85	Iannotti JP, Ciccone J, Buss DD, et al. Accuracy of office-based ultrasonography of the shoulder for the diagnosis of rotator cuff tears. <i>J Bone Joint Surg Am.</i> 2005;87(6):1305-1311.	19
Sharlene A. Teefey	13	Jon A. Jacobson	83	Crass JR, Craig EV, Thompson RC, Feinberg SB. Ultrasonography of the rotator cuff: surgical correlation. <i>J Clin Ultrasound.</i> 1984;12(8):487-491.	19
Pekka U. Farin	11	Marnix T. van Holsbeeck	73	Al-Shawi A, Badge R, Bunker T. The detection of full thickness rotator cuff tears using ultrasound. <i>J Bone Joint Surg Br.</i> 2008;90(7):889-892.	18
Jon A. Jacobson	11	Joseph O. de Jesus	72	Bretzke CA, Crass JR, Craig EV, Feinberg SB. Ultrasonography of the rotator cuff. Normal and pathologic anatomy. <i>Invest Radiol.</i> 1985;20(3):311-315.	16

cine (<https://onlinelibrary.wiley.com/journal/15509613>), a journal dedicated to all dimensions of medical US. The first article identified in the aforementioned journal was "Ultrasonography of the rotator cuff: Technique and normal anatomy," authored by Middleton et al (22). This journal specifically focuses on patient care, instrumental advances, and biological effects; therefore, it is a perfect designation for clinical US studies of the shoulder joint. The highest number of citations and citations per paper were identified in the *American Journal of Roentgenology* (<https://www.ajronline.org/>),

the world's longest continuously published general radiology journal since 1907. The journal is clinically oriented and relevant to routine radiology practice. In addition to the acoustics and radiology categories, we observed that some of the leading journals belonged to the fields of orthopedics, surgery, rehabilitation, and sports medicine. Interestingly, 9 of the 12 leading journals were listed in either the first or second quartile of the WoS ranking in at least one category, which indicates an overall high quality of the publications included in this study.





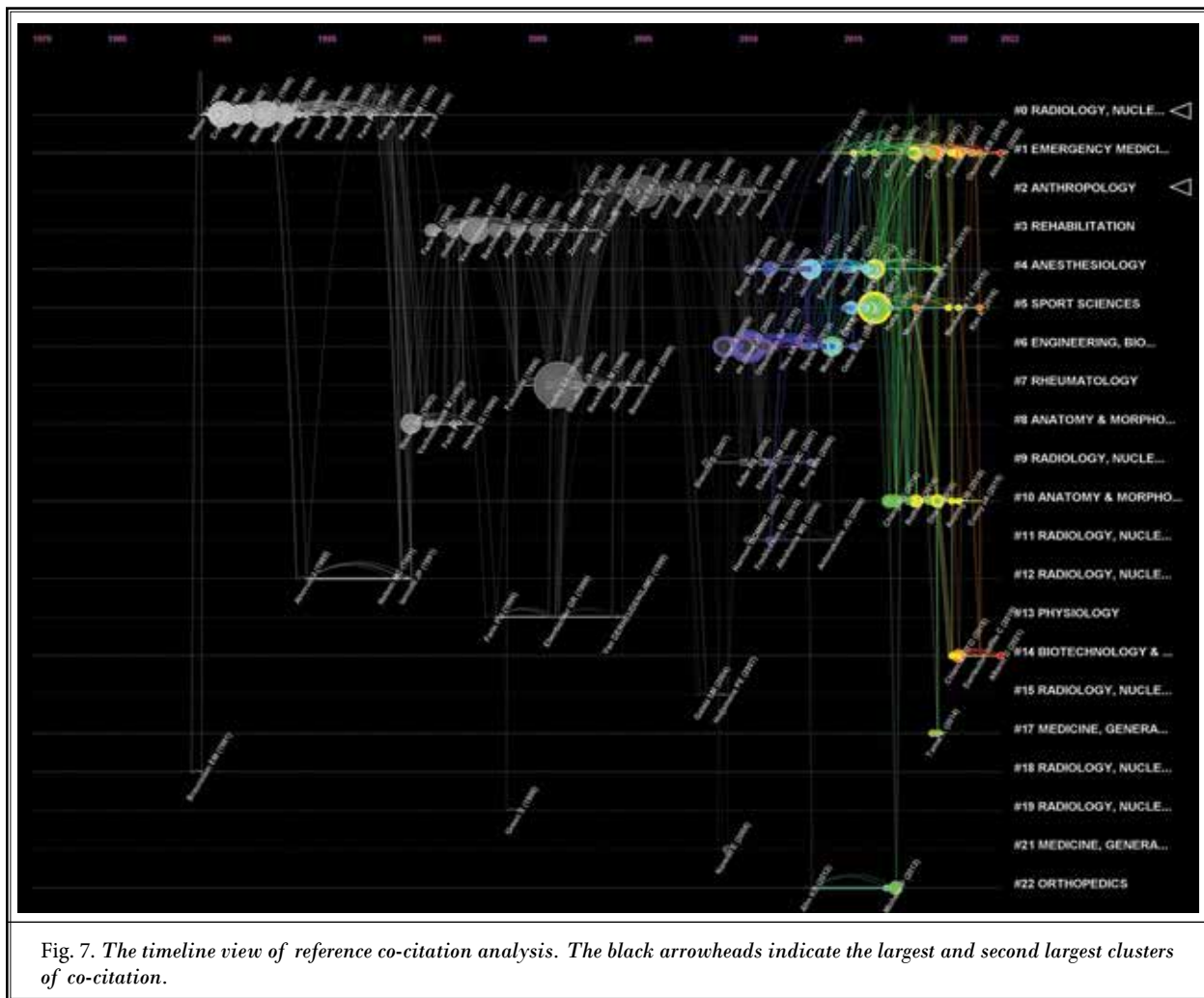
Moreover, we observed that 6 of the top 10 most-cited articles compared the utility of US imaging with that of arthroscopy or MRI for diagnosis of rotator cuff tendon tears, which may be attributable to the following factors: (i) A high prevalence of rotator cuff tendon tears in patients with shoulder pain (23) and a significant association between rotator cuff tears and upper extremity disability (24); (ii) US is widely used for effective diagnosis of rotator cuff tendon tears, with subsequent confirmatory arthroscopy or MRI (25).

The United States of America outnumbered other countries with regard to the number of publications (among those included in this study), which is attributable to the following factors: (i) The number of academicians with published work is higher in the United States of America; (ii) The United States of America was one of the first countries to develop musculoskeletal US. Interestingly, the 3 leading countries are located on different continents, which underscores the global trend of widespread popularity of US for evaluation of shoulder disorders.

With regard to institutions with the highest

number of publications, the League of European Research Universities (<https://www.leru.org/>) was ranked first, mainly because of the inclusion of 23 European universities that have focused on the aforementioned research. National Taiwan University was ranked second, perhaps because this institution has introduced systematic education of musculoskeletal US in recent years (26). Washington University in St. Louis had the highest number of citations and citation papers, mainly because it also had the most-cited publications (21) among our search results.

Keyword analysis revealed that "US" and "instability" were the first 2 words with the strongest citation bursts. The initial citation bursts showed that "US" was the common abbreviation used for ultrasound. "Instability" reflects the early application of US in the evaluation of dynamic shoulder disorders (27-29), which are difficult to evaluate using static imaging modalities such as computed tomography or MRI. Likewise, "sonography" showed the highest strength of citation bursts throughout the search period. "Arthroscopic findings" showed the second strongest citation burst,



which indicates the importance of a golden standard to validate US observations before US imaging becomes an acceptable modality to evaluate shoulder disorders (30). "Painful shoulder" was ranked third, which highlights the clinical utility of US in imaging/treating shoulder pain.

With regard to reference co-citation analysis, the most active citer to the largest cluster was "Ultrasound of the Shoulder and Elbow," authored by Ian Beggs (19). This article is a pictorial review that focuses on the use of US in the evaluation of shoulder and elbow disorders and is an early work that discusses US findings in patients with shoulder disorders. This study facilitated validation of the authors' observations by subsequent studies. "Rotator cuff tear: A clinical experience with sonographic detection," authored by Soble et al (20), was the most relevant citer to the second largest cluster.

This publication established the criteria for the use of US for the diagnosis of rotator cuff tears with validation from surgical observations. It is also an important milestone to consolidate the sensitivity and specificity of US for the detection of rotator cuff tears.

### Strengths and Limitations

To our knowledge, this bibliometric analysis is the first to quantitatively analyze scientific publications relevant to US imaging/modality for shoulder-related pain syndrome. This study may serve as a useful guideline for researchers; it will potentially improve awareness regarding the evolution of the target field and facilitate the development of future research proposals.

Following are the limitations of this study: (i) We only analyzed publications indexed in the WoS because most indicators required for bibliometric

Table 3. *The top articles with the most citation frequency.*

Title	First author	Journal	Year	Citation	Categories of Web of Science	Quartile
Detection and quantification of rotator cuff tears. Comparison of ultrasonographic, magnetic resonance imaging, and arthroscopic findings in seventy-one consecutive cases	Sharlene A. Teehey	<i>The Journal of Bone &amp; Joint Surgery</i>	2004	366	Orthopedics; Surgery	Q1; Q1
Accuracy of MRI, MR arthrography, and ultrasound in the diagnosis of rotator cuff tears: a meta-analysis	Joseph O. de Jesus	<i>American Journal of Roentgenology</i>	2009	332	Radiology, nuclear medicine & medical imaging	Q1
Ultrasonography of the rotator cuff. A comparison of ultrasonographic and arthroscopic findings in one hundred consecutive cases	Sharlene A. Teehey	<i>The Journal of Bone &amp; Joint Surgery</i>	2000	310	Orthopedics; Surgery	Q1; Q1
Symptomatic progression of asymptomatic rotator cuff tears: a prospective study of clinical and sonographic variables	Nathan A. Mall	<i>The Journal of Bone &amp; Joint Surgery</i>	2010	210	Orthopedics; Surgery	Q1; Q1
A randomized comparative study of short-term response to blind injection versus sonographic-guided injection of local corticosteroids in patients with painful shoulder	Esperanza Naredo	<i>The Journal of Rheumatology</i>	2004	203	Rheumatology	Q2
US evaluation of the rotator cuff	Laurence A. Mack	<i>Radiology</i>	1985	185	Radiology, nuclear medicine & medical imaging	Q1
Ultrasonographic evaluation of the rotator cuff and biceps tendon	William D. Middleton	<i>The Journal of Bone &amp; Joint Surgery</i>	1986	182	Orthopedics; Surgery	Q1; Q1
Ultrasound therapy for calcific tendinitis of the shoulder	Gerold R. Ebenbichler	<i>The New England Journal of Medicine</i>	1999	176	Medicine, general & internal	Q1
Rotator cuff tears: prospective comparison of MR imaging with arthrography, sonography, and surgery	D. Lawrence Burk	<i>American Journal of Roentgenology</i>	1989	173	Radiology, nuclear medicine & medical imaging	Q1
US depiction of partial-thickness tear of the rotator cuff	Marnix T. van Holsbeeck	<i>Radiology</i>	1995	173	Radiology, nuclear medicine & medical imaging	Q1

analysis can be efficiently extracted from its website. However, in our view, our results are representative because WoS is one of the most sophisticated multidisciplinary databases for documents and citations in academic journals (31). (ii) Articles focused on therapeutic US accounted for only 3.7% of the publications included in our study. Most top-ranking profiles of bibliometric indicators were associated with US imaging and guidance. Therefore, if researchers have a special interest in therapeutic US for shoulder disorders, an extension of the database and modification of algorithms during the literature search are essential to investigate the scientific performance of this small subgroup.

## CONCLUSION

This study highlights a significant trend of an increase in publications that have discussed the role of US for shoulder-related pain syndrome. However, the number of relevant citations appeared to have decreased after 2009, which indicates an early breakthrough (e.g., the utilization of advanced US technology or the introduction of novel pathophysiological concepts). This study, which included an analysis of global literature, indicates the exceptional popularity of US among researchers and health care practitioners for evaluation of shoulder (particularly rotator cuff) disorders. Further randomized controlled trials and state-of-the-art reviews are warranted to boost the citations and for

validation of US applications for shoulder-related pain syndrome.

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### Author Contributions

K.-V.C. conceived and designed the study, recruited the study subjects, and planned and performed the statistical analysis. L.Ö. made critical revisions to the manuscript. W.-T.W. and L.-R.C. conceived and designed the study. L.-R.C. and K.-V.C. performed the analysis

and interpretation of the data and wrote the draft; recruited the study subjects and performed the analysis and interpretation of the data; responsible for acquisition, analysis, and interpretation of the data. W.-Z.S., C.-P.L., and J.-A.L. contributed to study supervision and critical revision of the manuscript. J.-A.L. contributed to study supervision.

### Ethics Statement

Ethical review and approval were waived because this bibliometric study involved no human participants.

### Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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