ORIGINAL ARTICLE

Shoulder & Elbow

Shoulder & Elbow
2023, Vol. 15(3S) 82–93

DOI: 10.1177/17585732231155123
journals.sagepub.com/home/sel

Sage

The 50 most-cited articles in reverse shoulder arthroplasty

Benjamin D Gross, Christopher A White, Kevin C Wang, Akshar V Patel, Bradford O Parsons and Paul J Cagle

Abstract

Background: Citation analyses have been used to understand the impact that a group of publications has on its field. As the techniques and indications of reverse total shoulder arthroplasty (RTSA) continue to expand, it is important to identify articles that can orient readers to the history, evolution, and current status of the body of RTSA literature. The purpose of this study was to identify and analyze the 50 most-cited articles related to RTSA.

Methods: Various Boolean queries were searched on the Clarivate Analytics Web of Science. Information collected included author name, publication year, country of origin, journal name, article type, total number of citations, and level of evidence.

Results: Top 50 most-cited articles amassed a total of 10,521 citations. The most-cited article was cited a total of 766 times. The most common study designs were case series (28) and cohort studies (9). Authors from the United States (24) contributed the most to included papers, followed by France (19) and Switzerland (8).

Discussion: The most-cited articles on RTSA are expert opinions, case studies, and cohort studies published by American authors. As RTSA continues to grow over the next decade, studies with higher levels-of-evidence may overtake articles included in this analysis.

Keywords

Shoulder arthroplasty, reverse shoulder arthroplasty, bibliometric analysis, citation analysis

Date received: 6th September 2022; revised: 8th January 2023; accepted: 14th January 2023

Introduction

The first reverse shoulder prosthesis was reported in 1987 by Paul Grammont in France to treat end-stage rotator cuff arthropathy and pseudoparalysis.[1] Since Grammont's original design nearly 35 years ago, reverse total shoulder arthroplasty (RTSA) has become an effective option for treating a wide range of shoulder pathologies across an array of patient populations worldwide.[2–12] In the United States, RTSA has rapidly grown in popularity since its FDA approval in 2003, with annual utilization now surpassing that of anatomic total shoulder arthroplasty (ATSA).[13–15] Dramatic increases seen in the utilization of all shoulder arthroplasty over the last decade in the United States have largely been attributed to expanding use, indications, and familiarity with RTSA.[14,16–22] As indications expand and the aging population grows over the next decade, the overall incidence of RTSA is projected to continue increasing.[15,21,22]

Bibliometric or citation analyses have been used across academic literature to better understand and quantify the impact that a group of publications has on its field.[23–27] Numerous past studies in the orthopedic literature have undertaken bibliometric analyses to determine the most influential articles in the field, within subspecialties, and pertaining to specific procedures.[28–34] There has been one bibliometric review presenting the 50 most-cited articles in orthopedic shoulder surgery, however this publication only included 4 arthroplasty studies, none of which involved RTSA.[35] Another citation analysis evaluated the 50 most-cited publications in shoulder arthroplasty research, but this paper only included 18 publications directly relating to RTSA.[36]

As RTSA continues to make up a larger proportion of shoulder surgeries and arthroplasties performed in the United States, it is important to identify influential articles

Department of Orthopaedic Surgery, Icahn School of Medicine at Mount Sinai, New York, NY, USA

Corresponding author:
Benjamin D Gross, Department of Orthopaedic Surgery, Icahn School of Medicine at Mount Sinai, 1 Gustave L. Levy Place, New York, NY 10029, USA.
Email: benjamin.gross@icahn.mssm.edu

in this evolving area of clinical practice and research. Despite this, there has been limited bibliographic analysis dedicated to RTSA to date. While the number of citations is one of many variables to consider when evaluating the "importance" or "influence" of an article, it may help establish a set of "must-read" or "classic" articles that can be used in graduate and continuing medical education to highlight the contribution researchers and authors have made to the field of RTSA and provide historical perspective on RTSA.[35] Therefore, the purpose of this study was to identify the 50 most frequently cited articles related to RTSA in the orthopedic literature. We hypothesized that the publication year would have a significant impact on the number of citations an article generates.

Methods

Institutional review board approval was not obtained due to the public availability of the non-human data collected in this study. Clarivate Analytics Web of Science database was used to perform this analysis in a method similar manner to those outlined in previous orthopedic bibliometric analyses.[28,29,35] On 26 October 2021, various search queries using different Boolean combinations were undertaken until a search yielded the most number of results. The final search-term used to obtain the data in this study was the following: (TOPIC: (reverse OR inverted OR reverse total OR inverted total)) AND (TOPIC: (shoulder arthroplasty OR shoulder replacement)). There were no restrictions on language, journal, or country of origin in this search.

The list of articles that were returned by the aforementioned search-terms were then sorted in a descending fashion according to the number of citations. Titles and abstracts were reviewed to identify articles that were unrelated to RTSA. These studies were then excluded. If an article was a systematic review, only briefly mentioned RTSA, or if RTSA was not the main focus of the article, the article was excluded from this study. For example, one study examining long term outcomes of shoulder arthroplasty that included only a small number of RTSAs was excluded. Similar to inclusion criteria in previous analyses, articles that presented information on indications, procedural descriptions, techniques, outcomes, and outcomes of RTSA were included in this study.[28,29,35] If there was uncertainty after this screening, the full article was reviewed by the senior author (P.J.C.), a board-certified shoulder and elbow orthopedic surgeon, to determine whether it should be included or excluded from the study.

The top 50 most-cited articles were reviewed by the first three authors (B.D.G, C.A.W, and K.C.W) to obtain author name, publication year, country of origin (where each unique country of origin among the list of authors was counted once), journal name, article type (expert opinion, biomechanical study, case report, case series, case-control study, cohort study, randomized controlled trial, basic science, non-randomized control trial), total number of citations, and the level of evidence based on the guidelines published by *The Journal of Bone and Joint Surgery*.[37] Citation density (total number of citations divided by years since publication) was calculated on the basis of another study,[29] and recorded for each of the top 50 studies. All bibliometric metrics and data were recorded per year. The level of evidence and article type were independently determined by the first, second, and third authors. If a consensus on classification could not be reached by these authors, or if there was uncertainty about a classification, the senior author (P.J.C.) was called upon to make a final determination.

Results

The final search-term returned 3234 results on the Clarivate Analytics Web of Science database. The first 66 articles were reviewed in order to identify 50 articles that met the inclusion criteria, and could thus be considered in the top 50 articles relating to RTSA (Figure 1). Articles included in the top 50 were published between 2001 and 2016. More than half of the top 50 articles were published between 2005 and 2009, and 21 articles were published after 2009. Of these articles, the year with the most published articles was 2007 (8), followed by 2011 (7), 2008 (6), and 2009 (6) (Figure 2).

At the time of the search, the top 50 most-cited articles amassed a total of 10,521 citations, with an average of 16 citations per article per year. The most commonly cited article was cited a total of 766 times (Sirveaux et al.[38]), while the second and third most-cited articles were cited 582 and 567 times, respectively (Werner et al.[39] and Wall et al.[40]). The least cited article (Boileau et al.[41] 99 citations) had more than 650 fewer citations than the most-cited article. The year with the most total citations amassed across the top 50 articles was 2020 (1023 citations), followed closely by 2015 and 2019 (1020 citations and 1011 citations, respectively). There was significant growth in the number of citations that the top 50 articles collected per year between 2001 and 2015, followed by a relative plateau period with smaller increases and decreases between 2016 and 2021 (Figure 3).

The top 50 most-cited articles were also analyzed and compared on the basis citation density, calculated as the total number of citations divided by years since publication (Table 1). The article with the highest citation density was written by Sirveaux et al.[38] (45.1), while Wall et al.[40] and Boileau et al.[2] had articles with the second and third highest citation densities, respectively (40.5 and 37.4). Boileau[42] was the author of the most recently published article (2016), which ranked 38th in the number of citations (111) and 10th in citation density (22.2). The oldest article included in this study, written by Rittmeister and Kerschbaumer[43] in 2001, ranked 13th in the number of

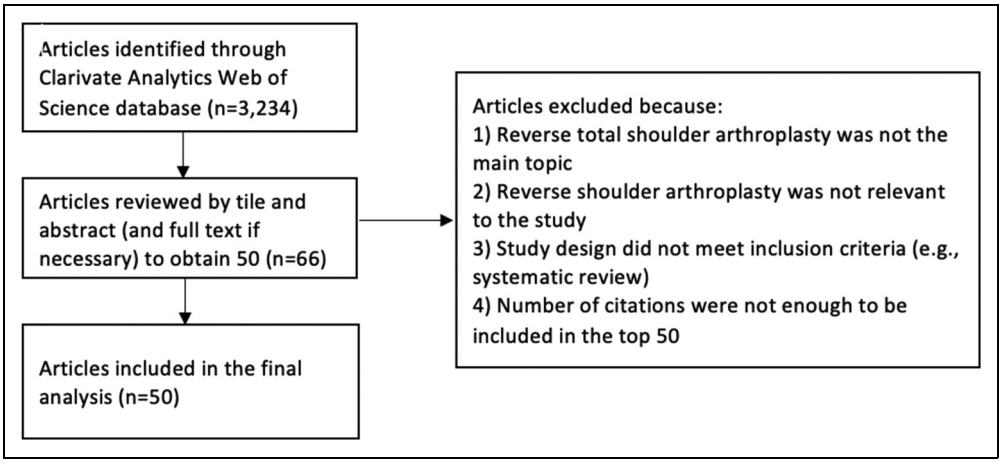

Figure 1. PRISMA (preferred reporting for systematic reviews and meta-analyses) flowchart used in this review.

citations (222) and 33rd in citation density (11.1). Articles published in 2010 or after (21) had an average citation density of 15.3, while articles published before 2010 (29) had an average citation density of 18.2.

Across the top 50 most-cited RTSA articles, Boileau had the greatest number of publications (6), followed by Cuff, Gerber, Gutierrez, Klein, Levigne, Levy, Melis, and Simovitch with 2 publications each. These articles were published across 9 unique journals, with *Journal of Joint and Bone Surgery* (American and British Volumes) being the most represented with 20 publications (Table 2). The articles originated from 10 different countries (Figure 4). Authors from the United States (24) contributed the most to included papers, followed closely by authors from France (19) and Switzerland (8) (Figure 4). Of the 10 oldest articles included in the study, French authors contributed to 6 and American authors contributed to 3 of these studies. The most common study design among the top 50 papers was case series (28) followed by cohort study (9) and expert opinion (7) (Table 3). Closely related, the most common levels of evidence were Level IV (29), Level V (11), and Level III (6) (Figure 5).

Discussion

This bibliometric analysis found that the top 50 most-cited articles in reverse shoulder arthroplasty were overwhelmingly case series studies (28) and studies with Level IV evidence (29), a finding that has been consistent across numerous bibliometric analyses in orthopedic surgery.[28–31,34,35] RTSA is a relatively new field in orthopedics (especially in the United States, where FDA approval was only obtained in 2003), which is likely a major factor contributing to the prevalence of expert opinion studies and case series in the top 50. This conclusion was consistent with those proposed in bibliometric analyses of other newer fields, such as hip arthroscopy and shoulder arthroscopy.[28,29] Similar to the notion proposed by Barbara et al., we believe that RTSA may be too young to see more randomized control trials, case-control studies, and other higher level-of-evidence studies represented in the top 50 most-cited articles.

As RTSA and its body of literature evolve over time, it is likely that the results and observations seen in this study will also evolve. One might expect that more randomized control trials and case-control studies will replace the expert-opinions and case series that currently predominate the top 50. Indeed, this is a trend that has been observed in bibliometric analyses of procedures with longer histories, such as hip and knee arthroplasty.[34,83] Because these study designs inherently minimize systematic-errors and research bias, their results are more likely to drastically shift clinical practice, thus becoming more heavily cited by subsequent studies in the field.

Although many of the top 50 most-cited RTSA studies are of a lower level-of-evidence, we do not believe that this detracts from their quality, or significance to the field of shoulder arthroplasty. The citation frequency of a scientific journal article is dependent on many factors including, but not limited to, the relevance and novelty of the findings, the quality of the work, the rigor of the research methodology and study design, and the ability of the work to change clinical practice or influence future research inquiries. Groundbreaking procedures, treatments, ideas, and research are often presented initially through observational studies with lower level-of-evidence.[35] As RTSA is still in its relatively early stages, many of today's most-cited articles may form the foundation that current and future higher level-of-evidence studies build upon in their research. Indeed, some of these studies may eventually be included in future analyses of the top 50 most-cited RTSA studies.

One interesting finding uncovered in this analysis was the large number of top 50 studies published between 2005 and 2009, with the majority of studies being published

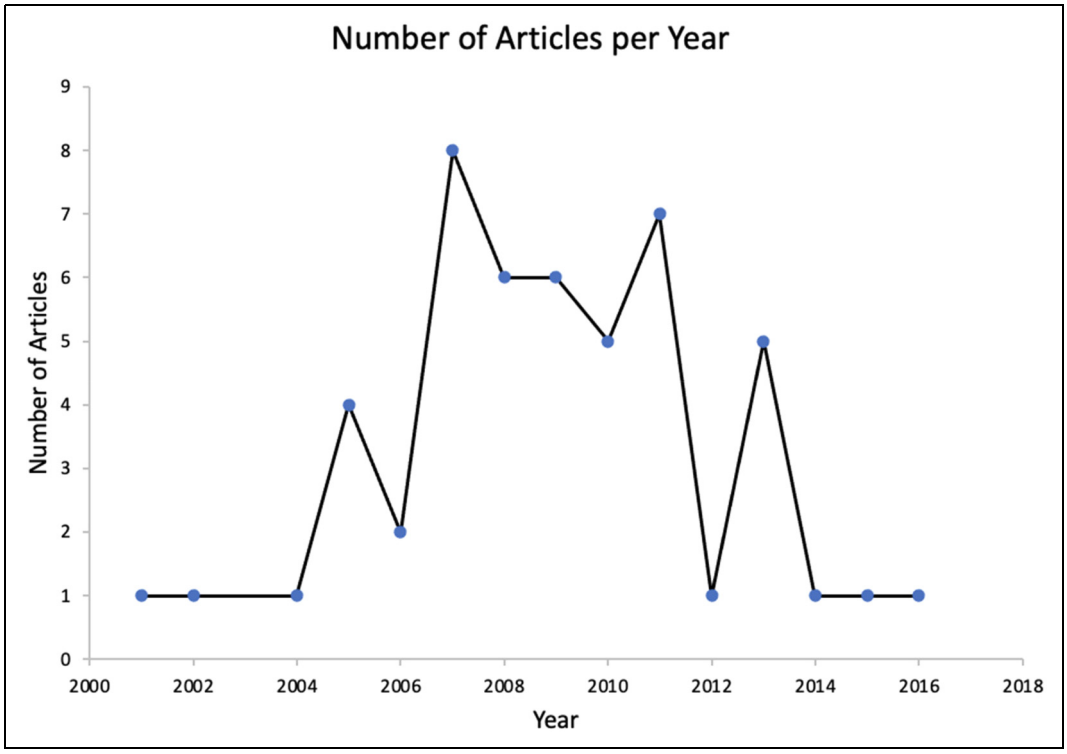

Figure 2. Sum of total top 50 reverse total shoulder arthroplasty articles published per year.

in or before 2009 (Figure 2). This is consistent with Barbera et al.'s finding that most-cited hip arthroscopy studies were published following 2007 with the largest spike in publications occurring in 2009.[28] Additionally, this aligns with the large spikes in publication seen in 2007 and 2005 for the most-cited shoulder arthroscopy studies examined by Moore et al.[29] Although it was unclear what actually contributed to the increases seen in the two aforementioned studies, the spike in our study was likely due this being the "earliest" period for RTSA in the United States. Numerous bibliometric analyses in orthopedics have shown that "time since publication" contributes significantly to the number of citations a study can amass.[25,28,29,32,35] Simply put, the longer a study has been published, the longer amount of time it has to obtain more citations. While this probably explains the relative spike seen between 2001 and 2009 in our study of RTSA, it could not explain why specifically the period from 2005 to 2009 had such a high prevalence of publications. Other bibliometric analysis mention a phenomenon called "obliteration by incorporation" proposed by Garfield et al. where new knowledge dominates in a field of research and frequency of citation decreases over time.[84] Essentially, as knowledge becomes widely accepted it stops getting cited. Accumulating citations being a time-dependent process versus obliteration by incorporation likely means there is a sweet-spot that will favor certain articles based on when the bibliometric analysis was conducted, with the case of RTSA likely being 2005–2009.

In addition to the length of time since publication, we found that the publishing journal and authors' country of origin may contribute to the total number of citations an article obtains. Almost half of the 50 most-cited articles were published in either the British or American Volumes of the *Journal of Joint and Bone Surgery,* with the *Journal of Shoulder and Elbow Surgery* publishing the second most articles. These observations were not surprising as these journals are popular, high-impact journals at the forefront of arthroplasty, and specifically shoulder arthroplasty. The majority of studies in the top 50 most-cited RTSA articles were produced by authors from the United States, a trend that has been seen in bibliometric analyses across orthopedic surgery and various other medical specialties.[24,28,29,31,35,85,86] It is unclear whether this observation points to biases in the publication process against non-American authors, the massive volume of research produced in the United States, or likely, some combination of both factors. Interestingly, French authors (19) were the second largest contributors to articles in the top 50, and also contributed to a majority (6) of the 10 oldest articles in the top 50 most-cited articles in this study. This unique trend likely reflects the large, pioneering contribution that French surgeons and researchers played in the development of the original reverse shoulder prosthesis.[1,87]

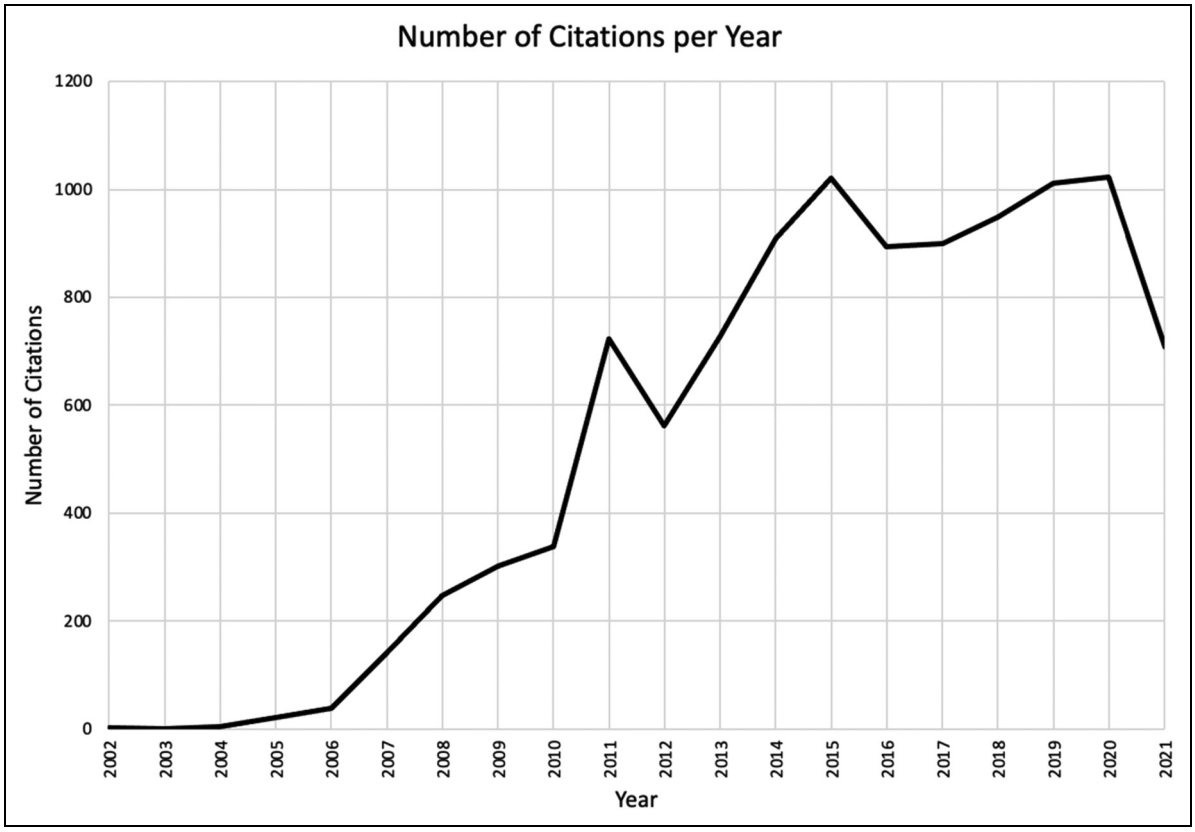

Figure 3. Total number of citations amassed by the top 50 reverse total shoulder arthroplasty articles per year. 2021 data is through October of this year.

Attention should be called to the papers that may be highly cited but are nonetheless outdated. Within the top third of papers, there are antiquated techniques described including six involving the approach or exposure, six regarding the positioning of implants, four about the use of drains, and three referencing patient selection. Four papers mentioned using the transacromial approach to the shoulder, which has been largely replaced by the deltopectoral and anterolateral approaches.[38,43,45,54] Two papers describe removing the tuberosities with or without re-attachment, which is no longer practiced, but rather the tuberosities are retained even if selective rotator cuff muscles are routinely released.[47,52] Initial RTSA designs moved the glenoid center of rotation laterally, which decreased the moment arm and increased the force necessary by the deltoid muscle that contributed to acromion stress fractures. Medializing the glenoid center of rotation was thought to be the solution, however, the rise in incidence of scapular notching and glenoid loosening has caused a shift back toward lateralizing the center of rotation. Despite this, four of the top 50 articles in RTSA promote medialization.[40,44,53,88] Two articles describe uncommonly used version of the glenoid and/or humeral component with Werner et al. describing glenoid retroversion of up to 10° and maintaining less than 20° of humeral retroversion, while Bufquin et al. utilized neutral version of the humeral component.[39,47] Furthermore, drains were once thought to be necessary due to enlargement of the subacromial space during RTSA as discussed by four of the top 50 articles.[39,45,48,53] However, it has since been shown that drains provide may provide limited benefit and actually increase complications.[89] Lastly, indications are constantly expanding, and occasionally contracting, for various procedures in orthopedic surgery, and we feel it should be noted that RTSA is no longer reserved for those >70 years of age, as some of the top 50 articles recommend.[2,44,45]

Similar to sentiments expressed by Namdari et al., we believe quantifying the top 50 most-cited articles in RTSA can provide orthopedists, from new residents to experienced attending shoulder surgeons, with a helpful "short-list" of articles that can orient the reader to the current status and evolution of the body of RTSA literature.[35] Especially as RTSA is poised to continue growing over the next decade, the articles included in this analysis can be used to build the foundation and perspective needed for critically-analyzing the next wave of research on this evolving topic. However, characterizing all studies as "must reads" for new residents as well as experienced

Table 1. The top 50 most-cited articles in reverse total shoulder arthroplasty.

Rank	Article	Number of citations	Citation density[a]
1	Grammont inverted total shoulder arthroplasty in the treatment of glenohumeral osteoarthritis with massive rupture of the cuff—Results of a multicentre study of 80 shoulders[38]	766	45.1
2	Treatment of painful pseudoparesis due to irreparable rotator cuff dysfunction with the delta III reverse-ball-and-socket total shoulder prosthesis[39]	582	36.4
3	Reverse total shoulder arthroplasty: A review of results according to etiology[40]	567	40.5
4	Neer Award 2005: The Grammont reverse shoulder prosthesis: Results in cuff tear arthritis, fracture sequelae, and revision arthroplasty[2]	561	37.4
5	Grammont reverse prosthesis: Design, rationale, and biomechanics[44]	545	34.1
6	The reverse shoulder prosthesis for glenohumeral arthritis associated with severe rotator cuff deficiency—A minimum two-year follow-up study of sixty patients[3]	510	31.9
7	Reverse total shoulder arthroplasty—Survivorship analysis of eighty replacements followed for five to ten years[45]	426	28.4
8	Reverse shoulder arthroplasty for the treatment of rotator cuff deficiency[46]	309	23.8
9	Reverse shoulder arthroplasty for the treatment of three- and four-part fractures of the proximal humerus in the elderly—A prospective review of 43 cases with a short-term follow-up[47]	287	20.5
10	Predictors of scapular notching in patients managed with the Delta III reverse total shoulder replacement[48]	271	19.4
11	Scapular notching in reverse shoulder arthroplasty[49]	243	18.7
12	Reverse Shoulder Arthroplasty for the Treatment of Irreparable Rotator Cuff Tear Without Glenohumeral Arthritis[50]	238	21.6
13	Grammont reverse total shoulder arthroplasty in patients with rheumatoid arthritis and nonreconstructible rotator cuff lesions[43]	222	11.1
14	The use of the reverse shoulder prosthesis for the treatment of failed hemiarthroplasty for proximal humeral fracture[51]	205	14.6
15	Three or four parts complex proximal humerus fractures: Hemiarthroplasty versus reverse prosthesis: A comparative study of 40 cases[52]	191	15.9
16	Reverse Total Shoulder Arthroplasty[53]	189	15.8
17	Reverse Prostheses in Arthropathies With Cuff Tear: Are Survivorship and Function Maintained Over Time?[54]	185	18.5
18	Early results of a reverse design prosthesis in the treatment of arthritis of the shoulder in elderly patients with a large rotator cuff tear[55]	180	9.5
19	Reverse total shoulder arthroplasty for massive irreparable rotator cuff tears in patients younger than 65 years old: Results after five to fifteen years[56]	175	21.9
20	Complications in Reverse Total Shoulder Arthroplasty[57]	168	16.8
21	Reverse total shoulder arthroplasty—From the most to the least common complication[58]	159	14.5
22		158	9.9

(continued)

Table 1. Continued

Rank	Article	Number of citations	Citation density[a]
	Initial glenoid component fixation in reverse total shoulder arthroplasty: A biomechanical evaluation[59]		
23	Reverse Total Shoulder Arthroplasty for Primary Glenohumeral Osteoarthritis in Patients with a Biconcave Glenoid[9]	158	19.8
24	Reverse total shoulder arthroplasty after failed rotator cuff surgery[60]	156	13.0
25	Range of Impingement-Free Abduction and Adduction Deficit After Reverse Shoulder Arthroplasty Hierarchy of Surgical and Implant-Design-Related Factors[61]	155	11.9
26	Use of the reverse shoulder prosthesis for the treatment of failed hemiarthroplasty in patients with glenohumeral arthritis and rotator cuff deficiency[62]	155	11.1
27	Comparison of Hemiarthroplasty and Reverse Shoulder Arthroplasty for the Treatment of Proximal Humeral Fractures in Elderly Patients[63]	144	18.0
28	Treatment of Comminuted Fractures of the Proximal Humerus in Elderly Patients With the Delta III Reverse Shoulder Prosthesis[64]	139	10.7
29	Reverse shoulder arthroplasty versus hemiarthroplasty for acute proximal humeral fractures. A blinded, randomized, controlled, prospective study[65]	139	19.9
30	The reverse shoulder prosthesis in the treatment of fractures of the proximal humerus in the elderly[66]	136	12.4
31	National utilization of reverse total shoulder arthroplasty in the United States[20]	135	22.5
32	The reverse total shoulder arthroplasty[67]	128	9.1
33	Reverse Total Shoulder Arthroplasty Improves Function in Cuff Tear Arthropathy[4]	127	12.7
34	Scapular Notching in Reverse Shoulder Arthroplasty: Is It Important to Avoid It and How?[68]	120	12.0
35	Subscapularis insufficiency and the risk of shoulder dislocation after reverse shoulder arthroplasty[69]	117	9.8
36	Functional outcomes of reverse shoulder arthroplasty compared with hemiarthroplasty for acute proximal humeral fractures[70]	117	14.6
37	Impact of fatty infiltration of the teres minor muscle on the outcome of reverse total shoulder arthroplasty[71]	114	8.1
38	Complications and revision of reverse total shoulder arthroplasty[42]	111	22.2
39	Reverse Total Shoulder Replacement: Intraoperative and Early Postoperative Complications[72]	111	9.3
40	Is Reverse Shoulder Arthroplasty Appropriate for the Treatment of Fractures in the Older Patient?: Early Observations[73]	106	10.6
41	An evaluation of the radiological changes around the Grammont reverse geometry shoulder arthroplasty after eight to 12 years[74]	106	10.6
42	Evaluation of abduction range of motion and avoidance of inferior scapular impingement in a reverse shoulder model[75]	104	8.0
43	Scapula Fractures After Reverse Total Shoulder Arthroplasty: Classification and Treatment[76]	104	10.4

(continued)

Table 1. Continued

Rank	Article	Number of citations	Citation density[a]
44	Indications for Reverse Total Shoulder Arthroplasty in Rotator Cuff Disease[77]	101	9.2
45	Reverse shoulder arthroplasty combined with a modified latissimus dorsi and teres major tendon transfer for shoulder pseudoparalysis associated with dropping arm[78]	101	7.8
46	Reverse delta-III total shoulder replacement combined with latissimus dorsi transfer—A preliminary report[79]	101	7.2
47	Glenoid morphology in reverse shoulder arthroplasty: Classification and surgical implications[80]	100	8.3
48	Glenoid loosening and failure in anatomical total shoulder arthroplasty: Is revision with a reverse shoulder arthroplasty a reliable option?[81]	100	11.1
49	Effects of Acquired Glenoid Bone Defects on Surgical Technique and Clinical Outcomes in Reverse Shoulder Arthroplasty[82]	100	9.1
50	Revision surgery of reverse shoulder arthroplasty[41]	99	12.4

[a]Calculated as total number of number of citations divided by years since publication.

Table 2. The top 50 most-cited articles in reverse total shoulder arthroplasty by publishing journal.

Journal	Number of articles
Clinical Orthopaedics and Related Research	8
International Orthopedics	1
The Journal of Bone & Joint Surgery	
American Volume	15
British Volume	5
Journal of Orthopaedic Trauma	1
Journal of Shoulder and Elbow Surgery	15
Journal of the American Academy of Orthopedic Surgeons	2
Orthopaedics & Traumatology—Surgery & Research	2
Orthopedics	1

surgeons based on their citation number/density may be problematic. For example, Boulahia et al.'s study reports early results of reverses for rotator cuff arthropathy.[55] Early results are undoubtedly useful to surgeons at the time of publication and to guide future research, but may not be particularly useful to surgeons when longer term data is readily available. Additionally, certain articles have lost relevance as techniques and implants have changed. Farshad and Gerber's study is a review of complication-rates from 2010, with the most common reported complication being scapular notching.[58] A more recent 2020 article by Parada et al. found a much lower rate of scapular notching.[90] Klein et al.'s article is a 2008 cohort study looking specifically at the Delta III implant, which has since been updated and is no longer in use.[64] With these concerns in mind, we believe that the "top articles" generated from this bibliometric analysis should be used to guide an initial selection of influential and important articles on RTSA; extra effort and discretion should be taken to refine any reading-list based on the most recent updates and evolutions to the field.

Limitations

Citation analyses, including this study, are associated with many limitations. First, using 50 articles as a cutoff was arbitrary, and there may have been other important and influential articles that were omitted. Second, a "snowball effect," as described in other bibliometric analyses, may have artificially inflated the number of citations an article received.[31,32,35] This theory states that authors are more likely to cite an article because it was previously cited, rather than citing it based on content or quality. Third, the total number of citations or citation density of an article can be artificially inflated by self-citations. In this case, authors who regularly publish are more likely to cite their own work and increase their number of citations. Fourth, authors are more likely to cite articles published in journals where they are seeking publication acceptance. Fifth, although inclusion and exclusion criteria were clearly defined and based on previous bibliometric analyses

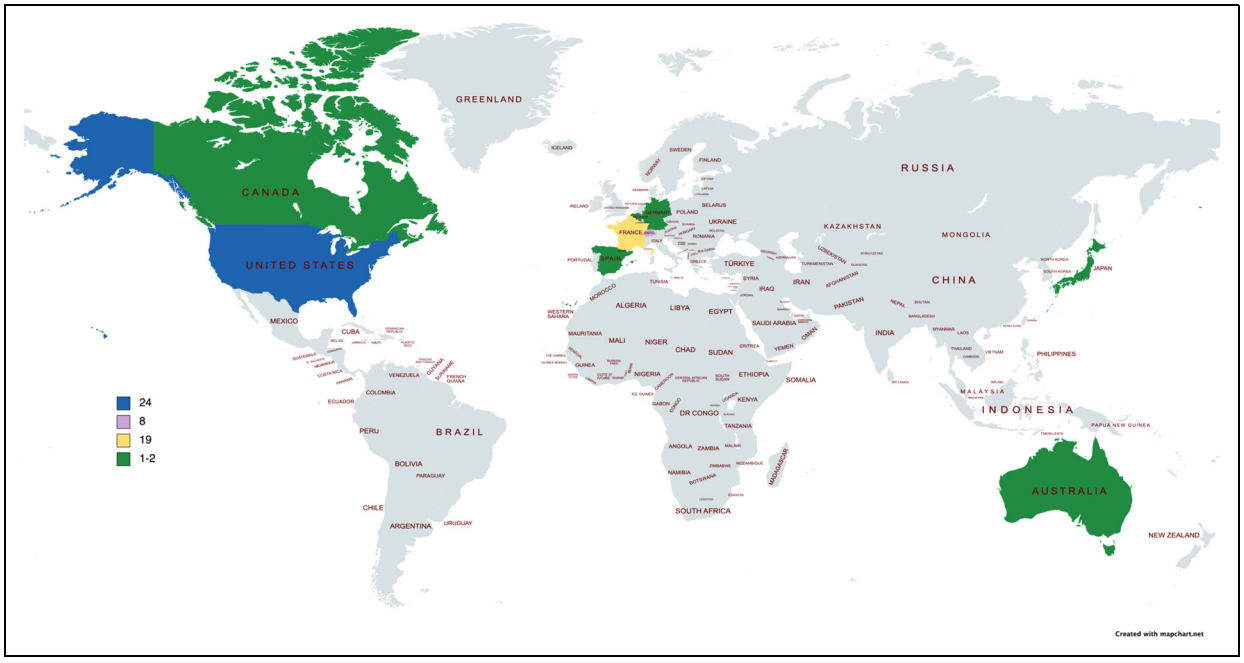

Figure 4. Geographical distribution of country of origin for authors of the top 50 most-cited articles in reverse total shoulder arthroplasty.

Table 3. The top 50 most-cited articles in reverse total shoulder arthroplasty by study type.

Type of study	Number of articles
Basic science	1
Biomechanical study	3
Case control	1
Case series	28
Cohort study	9
Expert opinion	7
Randomized controlled trial	1
Case report	0
Nonrandomized control trial	0

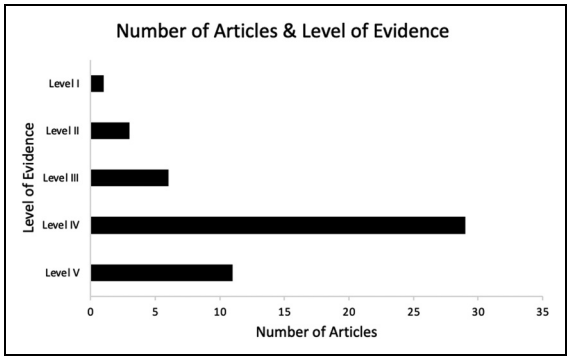

Figure 5. Level of evidence for the top 50 most-cited articles in reverse total shoulder arthroplasty.

in orthopedics, there was still some degree of inherent subjectivity in the selection of each article. In light of this, the authors incorporated various levels of article-review, across different levels of experience, to mitigate any bias or subjectivity in this regard.

Conclusions

A large proportion of the most-cited articles on RTSA are expert opinions, case studies, and cohort studies published by American authors. Additionally, the majority of articles were published between 2005 and 2009, likely owing to the relatively recent introduction of RTSA in the United States. As RTSA continues to grow over the next decade, studies with higher levels-of-evidence are expected to become more prominent in the field and may overtake articles included in this analysis. Ultimately, quantifying the top 50 most-cited articles in RTSA can provide a helpful "short-list" that will orient readers and provide a historical perspective on the current status and evolution of RTSA literature.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iDs

Benjamin D Gross https://orcid.org/0000-0003-2398-8472
Christopher A White https://orcid.org/0000-0002-8582-6105
Akshar V Patel https://orcid.org/0000-0001-8620-4802
Paul J Cagle https://orcid.org/0000-0002-9617-8369

References

1. Baulot E, Sirveaux F and Boileau P. Grammont's idea: the story of Paul Grammont's functional surgery concept and the development of the reverse principle. *Clin Orthop Relat Res* 2011; 469: 2425–2431.
2. Boileau P, Watkinson D, Hatzidakis AM, et al. Neer Award 2005: the Grammont reverse shoulder prosthesis: results in cuff tear arthritis, fracture sequelae, and revision arthroplasty. *J Shoulder Elbow Surg* 2006; 15: 527–540.
3. Frankle M, Levy JC, Pupello D, et al. The reverse shoulder prosthesis for glenohumeral arthritis associated with severe rotator cuff deficiency. a minimum two-year follow-up study of sixty patients surgical technique. *J Bone Joint Surg Am* 2006; 88: 178–190.
4. Nolan BM, Ankerson E and Wiater JM. Reverse total shoulder arthroplasty improves function in cuff tear arthropathy. *Clin Orthop Relat Res* 2011; 469: 2476–2482.
5. Alentorn-Geli E, Wanderman NR, Assenmacher AT, et al. Anatomic total shoulder arthroplasty with posterior capsular plication versus reverse shoulder arthroplasty in patients with biconcave glenoids: a matched cohort study. *J Orthop Surg* 2018; 26: 2309499018768570.
6. Chalmers PN and Keener JD. Expanding roles for reverse shoulder arthroplasty. *Curr Rev Musculoskelet Med* 2016; 9: 40–48.
7. Kelly JDII, Zhao JX, Hobgood ER, et al. Clinical results of revision shoulder arthroplasty using the reverse prosthesis. *J Shoulder Elbow Surg* 2012; 21: 1516–1525.
8. McFarland EG, Huri G, Hyun YS, et al. Reverse total shoulder arthroplasty without bone-grafting for severe glenoid bone loss in patients with osteoarthritis and intact rotator cuff. *J Bone Joint Surg Am* 2016; 98: 1801–1807.
9. Mizuno N, Denard PJ, Raiss P, et al. Reverse total shoulder arthroplasty for primary glenohumeral osteoarthritis in patients with a biconcave glenoid. *J Bone Joint Surg Am* 2013; 95: 1297–1304.
10. Smith CD, Guyver P and Bunker TD. Indications for reverse shoulder replacement: a systematic review. *J Bone Joint Surg Br* 2012; 94: 577–583.
11. Steen BM, Cabezas AF, Santoni BG, et al. Outcome and value of reverse shoulder arthroplasty for treatment of glenohumeral osteoarthritis: a matched cohort. *J Shoulder Elbow Surg* 2015; 24: 1433–1441.
12. Wright MA, Keener JD and Chamberlain AM. Comparison of clinical outcomes after anatomic total shoulder arthroplasty and reverse shoulder arthroplasty in patients 70 years and older with glenohumeral osteoarthritis and an intact rotator cuff. *J Am Acad Orthop Surg* 2020; 28: e222–e229.
13. Palsis JA, Simpson KN, Matthews JH, et al. Current trends in the use of shoulder arthroplasty in the United States. *Orthopedics* 2018; 41: e416–e423.
14. Kim SH, Wise BL, Zhang Y, et al. Increasing incidence of shoulder arthroplasty in the United States. *J Bone Joint Surg Am* 2011; 93: 2249–2254.
15. Rabinowitz J, Kothandaraman V, Lin J, et al. Utilization of shoulder arthroplasty in the United States—an analysis of current trends and future predictions. *Semin Arthroplasty* 2020; 30: 200–209.
16. Day JS, Lau E, Ong KL, et al. Prevalence and projections of total shoulder and elbow arthroplasty in the United States to 2015. *J Shoulder Elbow Surg* 2010; 19: 1115–1120.
17. Tashjian RZ. *Complex and revision shoulder arthroplasty: an evidence-based approach to evaluation and management*. Springer, 2019.
18. Issa K, Pierce CM, Pierce TP, et al. Total shoulder arthroplasty demographics, incidence, and complications—a nationwide inpatient sample database study. *Surg Technol Int* 2016; 29: 240–246.
19. Padegimas EM, Maltenfort M, Lazarus MD, et al. Future patient demand for shoulder arthroplasty by younger patients: national projections. *Clin Orthop Relat Res* 2015; 473: 1860–1867.
20. Schairer WW, Nwachukwu BU, Lyman S, et al. National utilization of reverse total shoulder arthroplasty in the United States. *J Shoulder Elbow Surg* 2015; 24: 91–97.
21. Wagner ER, Farley KX, Higgins I, et al. The incidence of shoulder arthroplasty: rise and future projections compared with hip and knee arthroplasty. *J Shoulder Elbow Surg* 2020; 29: 2601–2609.
22. Farley KX, Wilson JM, Kumar A, et al. Prevalence of shoulder arthroplasty in the United States and the increasing burden of revision shoulder arthroplasty. *J Bone Joint Surg* 2021; 6: e20.00156.
23. Garfield E. Citation analysis as a tool in journal evaluation. *Science* 1972; 178: 471–479.
24. Merigó JM and Núñez A. Influential journals in health research: a bibliometric study. *Global Health* 2016; 12: 46.
25. Adams AB and Simonson D. Publication, citations, and impact factors of leading investigators in critical care medicine. *Respir Care* 2004; 49: 276–281.
26. Wilson M, Sampson M, Barrowman N, et al. Bibliometric analysis of Neurology articles published in general medicine journals. *JAMA Netw Open* 2021; 4: e215840.
27. Antoniou GA, Antoniou SA, Georgakarakos EI, et al. Bibliometric analysis of factors predicting increased citations in the vascular and endovascular literature. *Ann Vasc Surg* 2015; 29: 286–292.
28. Barbera J, Selverian S, Courington R, et al. The top 50 most influential articles in hip arthroscopy. *Arthroscopy* 2020; 36: 716–722.
29. Moore ML, Pollock JR, McQuivey KS, et al. The top 50 most-cited shoulder arthroscopy studies. *Sports Med Arthrosc Rehabil Ther Technol* 2021; 3: e277–e287.
30. Baldwin KD, Kovatch K, Namdari S, et al. The 50 most cited articles in pediatric orthopedic surgery. *J Pediatr Orthop B* 2012; 21: 463–468.
31. Lefaivre KA, Shadgan B and O'Brien PJ. 100 most cited articles in orthopaedic surgery. *Clin Orthop Relat Res* 2011; 469: 1487–1497.

32. Ahmad SS, Evangelopoulos DS, Abbasian M, et al. The hundred most-cited publications in orthopaedic knee research. *J Bone Joint Surg Am* 2014; 96: e190.
33. Arshi A, Siesener NJ, McAllister DR, et al. The 50 most cited articles in orthopedic cartilage surgery. *Cartilage* 2016; 7: 238–247.
34. Holzer LA and Holzer G. The 50 highest cited papers in hip and knee arthroplasty. *J Arthroplasty* 2014; 29: 453–457.
35. Namdari S, Baldwin K, Kovatch K, et al. Fifty most cited articles in orthopedic shoulder surgery. *J Shoulder Elbow Surg* 2012; 21: 1796–1802.
36. Cohn MR, Mehta N, Kunze KN, et al. The fifty most cited publications in shoulder arthroplasty research. *Shoulder Elbow* 2022; 14: 368–377.
37. Wright JG, Swiontkowski MF and Heckman JD. Introducing levels of evidence to the journal. *J Bone Joint Surg Am* 2003; 85: 1–3.
38. Sirveaux F, Favard L, Oudet D, et al. Grammont inverted total shoulder arthroplasty in the treatment of glenohumeral osteoarthritis with massive rupture of the cuff. Results of a multicentre study of 80 shoulders. *J Bone Joint Surg Br* 2004; 86: 388–395.
39. Werner CML, Steinmann PA, Gilbart M, et al. Treatment of painful pseudoparesis due to irreparable rotator cuff dysfunction with the Delta III reverse-ball-and-socket total shoulder prosthesis. *J Bone Joint Surg Am* 2005; 87: 1476–1486.
40. Wall B, Nové-Josserand L, O'Connor DP, et al. Reverse total shoulder arthroplasty: a review of results according to etiology. *J Bone Joint Surg Am* 2007; 89: 1476–1485.
41. Boileau P, Melis B, Duperron D, et al. Revision surgery of reverse shoulder arthroplasty. *J Shoulder Elbow Surg* 2013; 22: 1359–1370.
42. Boileau P. Complications and revision of reverse total shoulder arthroplasty. *Orthop Traumatol Surg Res* 2016; 102: S33–S43.
43. Rittmeister M and Kerschbaumer F. Grammont reverse total shoulder arthroplasty in patients with rheumatoid arthritis and nonreconstructible rotator cuff lesions. *J Shoulder Elbow Surg* 2001; 10: 17–22.
44. Boileau P, Watkinson DJ, Hatzidakis AM, et al. Grammont reverse prosthesis: design, rationale, and biomechanics. *J Shoulder Elbow Surg* 2005; 14: 147S–161S.
45. Guery J, Favard L, Sirveaux F, et al. Reverse total shoulder arthroplasty. Survivorship analysis of eighty replacements followed for five to ten years. *J Bone Joint Surg Am* 2006; 88: 1742–1747.
46. Cuff D, Pupello D, Virani N, et al. Reverse shoulder arthroplasty for the treatment of rotator cuff deficiency. *J Bone Joint Surg Am* 2008; 90: 1244–1251.
47. Bufquin T, Hersan A, Hubert L, et al. Reverse shoulder arthroplasty for the treatment of three- and four-part fractures of the proximal humerus in the elderly: a prospective review of 43 cases with a short-term follow-up. *J Bone Joint Surg Br* 2007; 89: 516–520.
48. Simovitch RW, Zumstein MA, Lohri E, et al. Predictors of scapular notching in patients managed with the Delta III reverse total shoulder replacement. *J Bone Joint Surg Am* 2007; 89: 588–600.
49. Lévigne C, Boileau P, Favard L, et al. Scapular notching in reverse shoulder arthroplasty. *J Shoulder Elbow Surg* 2008; 17: 925–935.
50. Mulieri P, Dunning P, Klein S, et al. Reverse shoulder arthroplasty for the treatment of irreparable rotator cuff tear without glenohumeral arthritis. *J Bone Joint Surg Am* 2010; 92: 2544–2556.
51. Levy J, Frankle M, Mighell M, et al. The use of the reverse shoulder prosthesis for the treatment of failed hemiarthroplasty for proximal humeral fracture. *J Bone Joint Surg Am* 2007; 89: 292–300.
52. Gallinet D, Clappaz P, Garbuio P, et al. Three or four parts complex proximal humerus fractures: hemiarthroplasty versus reverse prosthesis: a comparative study of 40 cases. *Orthop Traumatol Surg Res* 2009; 95: 48–55.
53. Gerber C, Pennington SD and Nyffeler RW. Reverse total shoulder arthroplasty. *J Am Acad Orthop Surg* 2009; 17: 284–295.
54. Favard L, Levigne C, Nerot C, et al. Reverse prostheses in arthropathies with cuff tear: are survivorship and function maintained over time? *Clin Orthop Relat Res* 2011; 469: 2469–2475.
55. Boulahia A, Bradley Edwards T, Walch G, et al. Early results of a reverse design prosthesis in the treatment of arthritis of the shoulder in elderly patients with a large rotator cuff tear. *Orthopedics* 2002; 25: 129–133.
56. Ek ETH, Neukom L, Catanzaro S, et al. Reverse total shoulder arthroplasty for massive irreparable rotator cuff tears in patients younger than 65 years old: results after five to fifteen years. *J Shoulder Elbow Surg* 2013; 22: 1199–1208.
57. Cheung E, Willis M, Walker M, et al. Complications in reverse total shoulder arthroplasty. *J Am Acad Orthop Surg* 2011; 19: 439–449.
58. Farshad M and Gerber C. Reverse total shoulder arthroplasty —from the most to the least common complication. *Int Orthop* 2010; 34: 1075–1082.
59. Harman M, Frankle M, Vasey M, et al. Initial glenoid component fixation in "reverse" total shoulder arthroplasty: a biomechanical evaluation. *J Shoulder Elbow Surg* 2005; 14: 162S–167S.
60. Boileau P, Gonzalez JF, Chuinard C, et al. Reverse total shoulder arthroplasty after failed rotator cuff surgery. *J Shoulder Elbow Surg* 2009; 18: 600–606.
61. Gutiérrez S, Comiskey CAIV, Luo ZP, et al. Range of impingement-free abduction and adduction deficit after reverse shoulder arthroplasty. Hierarchy of surgical and implant-design-related factors. *J Bone Joint Surg Am* 2008; 90: 2606–2615.
62. Levy JC, Virani N, Pupello D, et al. Use of the reverse shoulder prosthesis for the treatment of failed hemiarthroplasty in patients with glenohumeral arthritis and rotator cuff deficiency. *J Bone Joint Surg Br* 2007; 89: 189–195.
63. Cuff DJ and Pupello DR. Comparison of hemiarthroplasty and reverse shoulder arthroplasty for the treatment of proximal humeral fractures in elderly patients. *J Bone Joint Surg Am* 2013; 95: 2050–2055.
64. Klein M, Juschka M, Hinkenjann B, et al. Treatment of comminuted fractures of the proximal humerus in elderly patients with the Delta III reverse shoulder prosthesis. *J Orthop Trauma* 2008; 22: 698–704.
65. Sebastiá-Forcada E, Cebrián-Gómez R, Lizaur-Utrilla A, et al. Reverse shoulder arthroplasty versus hemiarthroplasty for acute proximal humeral fractures. A blinded, randomized, controlled, prospective study. *J Shoulder Elbow Surg* 2014; 23: 1419–1426.

66. Cazeneuve JF and Cristofari DJ. The reverse shoulder prosthesis in the treatment of fractures of the proximal humerus in the elderly. *J Bone Joint Surg Br* 2010; 92: 535–539.
67. Matsen FAIII, Boileau P, Walch G, et al. The reverse total shoulder arthroplasty. *J Bone Joint Surg Am* 2007; 89: 660–667.
68. Lévigne C, Garret J, Boileau P, et al. Scapular notching in reverse shoulder arthroplasty: is it important to avoid it and how? *Clin Orthop Relat Res* 2011; 469: 2512–2520.
69. Edwards TB, Williams MD, Labriola JE, et al. Subscapularis insufficiency and the risk of shoulder dislocation after reverse shoulder arthroplasty. *J Shoulder Elbow Surg* 2009; 18: 892–896.
70. Boyle MJ, Youn SM, Frampton CMA, et al. Functional outcomes of reverse shoulder arthroplasty compared with hemiarthroplasty for acute proximal humeral fractures. *J Shoulder Elbow Surg* 2013; 22: 32–37.
71. Simovitch RW, Helmy N, Zumstein MA, et al. Impact of fatty infiltration of the teres minor muscle on the outcome of reverse total shoulder arthroplasty. *J Bone Joint Surg Am* 2007; 89: 934–939.
72. Wierks C, Skolasky RL, Ji JH, et al. Reverse total shoulder replacement: intraoperative and early postoperative complications. *Clin Orthop Relat Res* 2009; 467: 225–234.
73. Lenarz C, Shishani Y, McCrum C, et al. Is reverse shoulder arthroplasty appropriate for the treatment of fractures in the older patient? Early observations. *Clin Orthop Relat Res* 2011; 469: 3324–3331.
74. Melis B, DeFranco M, Lädermann A, et al. An evaluation of the radiological changes around the Grammont reverse geometry shoulder arthroplasty after eight to 12 years. *J Bone Joint Surg Br* 2011; 93: 1240–1246.
75. Gutiérrez S, Levy JC, Frankle MA, et al. Evaluation of abduction range of motion and avoidance of inferior scapular impingement in a reverse shoulder model. *J Shoulder Elbow Surg* 2008; 17: 608–615.
76. Crosby LA, Hamilton A and Twiss T. Scapula fractures after reverse total shoulder arthroplasty: classification and treatment. *Clin Orthop Relat Res* 2011; 469: 2544–2549.
77. Drake GN, O'Connor DP and Edwards TB. Indications for reverse total shoulder arthroplasty in rotator cuff disease. *Clin Orthop Relat Res* 2010; 468: 1526–1533.
78. Boileau P, Chuinard C, Roussanne Y, et al. Reverse shoulder arthroplasty combined with a modified latissimus dorsi and teres major tendon transfer for shoulder pseudoparalysis associated with dropping arm. *Clin Orthop Relat Res* 2008; 466: 584–593.
79. Gerber C, Pennington SD, Lingenfelter EJ, et al. Reverse Delta-III total shoulder replacement combined with latissimus dorsi transfer. A preliminary report. *J Bone Joint Surg Am* 2007; 89: 940–947.
80. Frankle MA, Teramoto A, Luo ZP, et al. Glenoid morphology in reverse shoulder arthroplasty: classification and surgical implications. *J Shoulder Elbow Surg* 2009; 18: 874–885.
81. Melis B, Bonnevialle N, Neyton L, et al. Glenoid loosening and failure in anatomical total shoulder arthroplasty: is revision with a reverse shoulder arthroplasty a reliable option? *J Shoulder Elbow Surg* 2012; 21: 342–349.
82. Klein SM, Dunning P, Mulieri P, et al. Effects of acquired glenoid bone defects on surgical technique and clinical outcomes in reverse shoulder arthroplasty. *J Bone Joint Surg Am* 2010; 92: 1144–1154.
83. Piuzzi NS, Sultan AA, Gatta J, et al. Top 100 most-cited clinical studies of hip and knee arthroplasty: the foundation of practice. *Orthopedics* 2019; 42: e151–e161.
84. Garfield E. 100 Citation classics from the Journal of the American Medical Association. *JAMA* 1987; 257: 52–59.
85. Loonen MPJ, Hage JJ and Kon M. Plastic surgery classics: characteristics of 50 top-cited articles in four plastic surgery journals since 1946. *Plast Reconstr Surg* 2008; 121: 320e–327e.
86. Paladugu R, Schein M, Gardezi S, et al. One hundred citation classics in general surgical journals. *World J Surg* 2002; 26: 1099–1105.
87. Flatow EL and Harrison AK. A history of reverse total shoulder arthroplasty. *Clin Orthop Relat Res* 2011; 469: 2432–2439.
88. Frankle M, Siegal S, Pupello D, et al. The reverse shoulder prosthesis for glenohumeral arthritis associated with severe rotator cuff deficiency. A minimum two-year follow-up study of sixty patients. *J Bone Joint Surg Am* 2005; 87: 1697–1705.
89. Erickson BJ, Campbell K, Akshay Jain BS, et al. Are postoperative drains beneficial in total and reverse total shoulder arthroplasty? *Orthop Res Traumatol Open J* 2016; 1: 22–27.
90. Parada SA, Flurin PH, Wright TW, et al. Comparison of complication types and rates associated with anatomic and reverse total shoulder arthroplasty. *J Shoulder Elbow Surg* 2021; 30: 811–818.