

Bone Quality and Osteoporosis in Shoulder Surgery: A Bibliometric Analysis of Research Trends (2010–2025)

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Abstract

Purpose. To map the literature on bone quality and osteoporosis in shoulder surgery published between 2010 and 2025 using bibliometric methods, describing publication and citation trends, journal and author productivity, collaboration, influential articles, and major themes. **Methods.** The Lens database was searched on 3 July 2026 for journal articles and reviews whose title contained a shoulder term and whose title or abstract contained a bone-quality or osteoporosis term. Seven hundred eighty-eight records published between 2010 and 2025 were analyzed for annual output, citation impact, journal and author productivity, collaboration, most-cited articles, and thematic co-occurrence. **Results.** Annual output rose from 24 articles in 2010 to 109 in 2025 (compound annual growth rate, 10.6%). The articles received 11 596 citations (mean 14.7 per article), and the open-access share rose from 12% to about 70%. Thirteen core journals produced roughly one third of output, led by the Journal of Shoulder and Elbow Surgery; author productivity followed a Lotka distribution, and collaboration was high (mean 5.4 authors per article). The most-cited articles linked bone quality to rotator cuff healing, proximal humerus fracture fixation, and shoulder arthroplasty. **Conclusion.** Research on bone quality and osteoporosis in shoulder surgery has grown rapidly and is concentrated in a small core of subspecialty journals produced by a broad, collaborative author community, with the highest-impact work linking bone quality to clinical outcomes.

Keywords: Bibliometrics; Osteoporosis; Bone density; Shoulder; Rotator cuff; Arthroplasty.

1. Introduction

Bone quality is a decisive factor in shoulder surgery. Low bone mineral density reduces the pull-out strength of suture anchors in rotator cuff repair¹, compromises the stability of internal fixation in proximal humerus fractures², and influences implant loosening and selection in shoulder arthroplasty. As the population ages and the volume of rotator cuff repair, fracture fixation, and arthroplasty procedures rises, interest in assessing local bone quality — through dual-energy X-ray absorptiometry, the deltoid tuberosity index⁴, and computed tomography Hounsfield units⁵ — has grown correspondingly, and

osteoporosis is increasingly recognized as an independent, modifiable risk factor in this setting³.

Across the three principal shoulder procedures, poor bone quality has distinct consequences. In rotator cuff repair it predisposes to anchor loosening, pull-out, and retear; in proximal humerus fractures it undermines screw purchase and predicts fixation failure; and in shoulder arthroplasty it affects component seating, stress shielding, and aseptic loosening. These shared vulnerabilities have driven a search for practical, opportunistic tools to quantify local bone quality before surgery.

Despite this expanding body of work, the field has not been mapped quantitatively. Bibliometric analysis characterizes the structure, growth, and intellectual landscape of a research area⁶, and classic regularities such as Bradford's law of journal scattering¹³ and Lotka's law of author productivity¹⁴ further describe how a literature is organized. No bibliometric analysis has specifically addressed the intersection of bone quality or osteoporosis and shoulder surgery. The purpose of this study was to perform a comprehensive bibliometric analysis of this literature published between 2010 and 2025, describing publication and citation trends, the productivity and collaboration structure of journals and authors, the most-cited articles, and the principal research themes.

2. Materials and Methods

2.1. Study design and ethical considerations

This study was designed as a retrospective bibliometric analysis of publicly available bibliographic metadata. It did not involve human participants, identifiable personal information, biological materials, or animal subjects. Therefore, ethics committee approval and informed consent were not required.

2.2. Literature search and eligibility criteria

The Lens scholarly database (Lens.org), a freely accessible platform that aggregates records from sources including Crossref, PubMed, and OpenAlex⁷, was searched on 3 July 2026. To minimize variation caused by continuous database updating, all records were retrieved on the same day. The search covered publications dated from 1 January 2010 through 31 December 2025. Journal articles and reviews were eligible for inclusion. A shoulder-related term was required in the article title, whereas a bone-quality or osteoporosis-related term was required in the title or abstract. The search concepts were: shoulder OR "rotator cuff" OR "proximal humerus" OR "humeral head" OR glenoid; and "bone mineral density" OR "bone quality" OR osteoporosis OR osteopenia OR "Hounsfield unit" OR "bone density". No language restriction was applied. After the database filters were applied, 788 records were retrieved, and no additional records were excluded.

2.3. Data extraction and processing

The eligible records were exported with all available metadata. Extracted variables included article title, publication year, journal title, complete author list, citation count, open-access status, document type, and database-assigned fields of study. These data were organized at the article level and used to construct the annual, journal, author, citation, open-access, and thematic datasets.

2.4. Bibliometric indicators

Annual and cumulative publication counts were calculated to evaluate temporal growth. The compound annual growth rate was calculated from the publication counts in 2010 and 2025. Citation impact was summarized using total, mean, and median citations per article, the number of uncited publications, the number of highly cited publications (defined as at least 100 citations), and the h-index of the complete corpus. Annual open-

access proportions were calculated from the open-access status provided in the database metadata.

2.5. Journal, author, and thematic analyses

Journals were ranked by publication count, total citations, and mean citations per article. To describe journal concentration, journals were ordered by productivity and divided into three zones containing approximately equal numbers of publications, representing a Bradford-type scattering pattern. Author productivity was evaluated according to the number of publications attributed to each author. The resulting frequency distribution was interpreted descriptively in relation to the right-skewed pattern commonly associated with Lotka's law; no formal goodness-of-fit test was performed. Collaboration was summarized using the mean number of authors per article and the proportion of multi-authored publications. Thematic structure was assessed through co-occurrence counts of database-assigned fields of study. Clearly irrelevant algorithmic classifications were removed before visualization, whereas related but non-identical database terms were retained separately to avoid altering the original metadata.

2.6. Statistical analysis

Analyses were performed in Python using the pandas and Matplotlib libraries, following established bibliometric guidance⁶. Continuous bibliometric variables are reported as means and medians, as appropriate, and categorical variables as frequencies and percentages. The analyses were descriptive, and no inferential hypothesis testing was performed. Citation counts were not normalized for citation exposure time; consequently, findings for recently published articles were interpreted in light of their shorter citation windows.

3. Results

Study corpus and publication growth. The final corpus comprised 788 journal articles and reviews published between 2010 and 2025 in 307 journals. Annual publication output increased from 24 articles in 2010 to 109 in 2025, representing a 4.5-fold rise and a compound annual growth rate of 10.6% (Figure 1). Output remained below 40 articles annually through 2016, increased to 41 in 2017, and accelerated after 2019. The five most recent years accounted for 387 publications (49.1% of the corpus), including 88 articles in 2024 and 109 in 2025. The cumulative curve therefore became progressively steeper toward the end of the study period, indicating sustained rather than isolated growth.

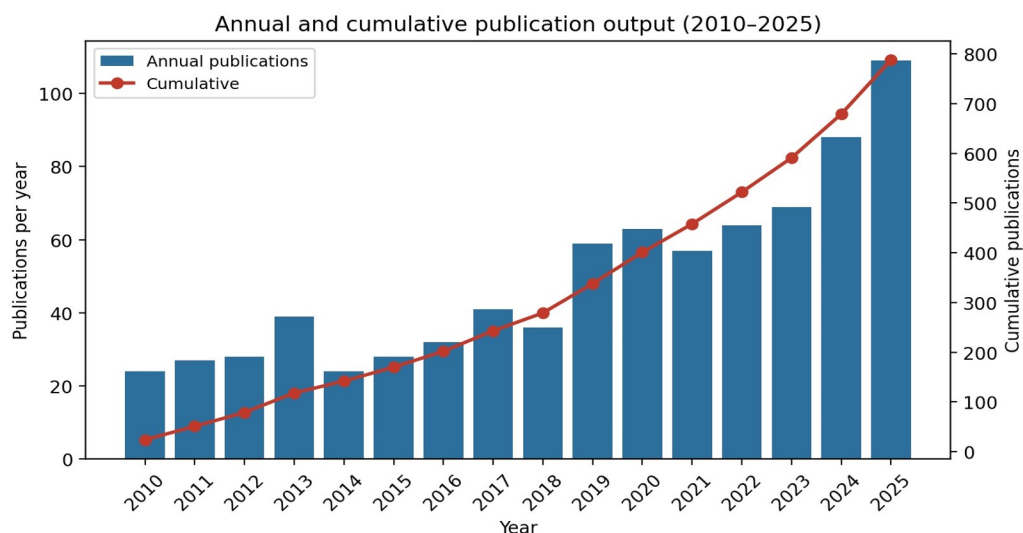
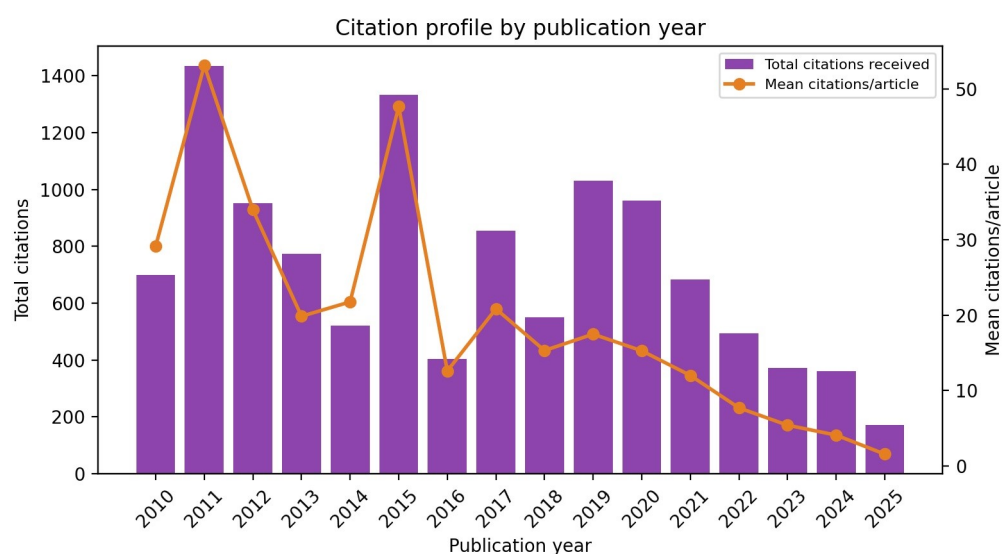


Figure 1. Annual and cumulative publication output, 2010–2025.

Table 1. Annual publication and citation indicators

Year	Articles	Total citations	Mean citations/article	Open access (%)
2010	24	699	29.1	12
2011	27	1434	53.1	19
2012	28	951	34.0	21
2013	39	774	19.8	23
2014	24	522	21.8	29
2015	28	1334	47.6	50
2016	32	403	12.6	16
2017	41	854	20.8	59
2018	36	551	15.3	39
2019	59	1031	17.5	46
2020	63	962	15.3	65
2021	57	684	12.0	56
2022	64	493	7.7	59
2023	69	373	5.4	77
2024	88	360	4.1	69
2025	109	171	1.6	67

Citation performance. The included publications had received 11,596 citations by the search date, with a mean of 14.7 and a median of 4 citations per article. The corpus h-index was 52. Eighteen articles (2.3%) had received at least 100 citations, whereas 233 articles (29.6%) had not yet been cited. Citation volume varied substantially by publication year (Table 1 and Figure 2). Articles published in 2011 accumulated the largest number of citations ($n = 1,434$) and the highest mean citation rate (53.1 per article), largely because that year contained two of the most influential articles in the dataset. Mean citation counts were lower in the most recent years, declining to 7.7 in 2022, 5.4 in 2023, 4.1 in 2024, and 1.6 in 2025, a pattern consistent with the shorter time available for citation accrual.

**Figure 2.** Citation profile by publication year (total citations and mean citations per article).

Journal productivity and concentration. The Journal of Shoulder and Elbow Surgery was the dominant source, publishing 86 articles (10.9% of the corpus), more than three

times the output of the second-ranked journal, Arthroscopy (n = 24). JSES International (n = 20), BMC Musculoskeletal Disorders (n = 16), and the Journal of Orthopaedic Research and Journal of Bone and Joint Surgery (British Volume) (n = 15 each) completed the leading group (Table 2). A Bradford-type concentration pattern was observed: 13 core journals contributed approximately one third of all articles, 62 journals contributed the next third, and the remaining third was dispersed across 232 journals. Thus, although the literature was distributed across more than 300 titles, a relatively compact group of shoulder, sports-medicine, trauma, and orthopaedic journals served as the principal publication outlets.

Table 2. Ten most productive journals by article count

Rank	Journal	Articles (n)
1	Journal of Shoulder and Elbow Surgery	86
2	Arthroscopy	24
3	JSES International	20
4	BMC Musculoskeletal Disorders	16
5	Journal of Orthopaedic Research	15
6	Journal of Bone and Joint Surgery (British Volume)	15
7	American Journal of Sports Medicine	14
8	International Journal of Orthopaedics Sciences	14
9	Injury	13
10	Journal of Clinical Medicine	12

Journal citation impact. Ranking journals by citation impact produced a somewhat different hierarchy (Table 3). The Journal of Shoulder and Elbow Surgery remained first in total citations (2,832; mean 32.9 per article). Injury ranked second in total citations despite publishing only 13 articles, with 862 citations and the highest mean citation count among the ten leading journals (66.3 per article). The American Journal of Sports Medicine likewise combined a modest article count (n = 14) with a high mean citation rate (53.9). Arthroscopy ranked fourth by total citations (671 citations), while Orthopedics, International Orthopaedics, and Clinical Orthopaedics and Related Research also contributed highly cited papers. These findings show that publication volume and average influence were related but not interchangeable dimensions of journal performance.

Table 3. Ten most-cited journals

Rank	Journal	Articles (n)	Total citations	Mean citations/article
1	Journal of Shoulder and Elbow Surgery	86	2832	32.9
2	Injury	13	862	66.3
3	American Journal of Sports Medicine	14	755	53.9
4	Arthroscopy	24	671	28.0
5	Orthopedics	8	330	41.2
6	International Orthopaedics	10	309	30.9
7	Journal of the American Academy of Orthopaedic Surgeons	11	269	24.5
8	Clinical Orthopaedics and Related Research	10	266	26.6
9	Journal of Orthopaedic Trauma	11	263	23.9
10	Journal of Bone and Joint Surgery	8	250	31.2

Author productivity and collaboration. A total of 3,422 unique authors contributed to the corpus. Articles had a mean of 5.4 authors, and 93% were multi-authored, demonstrating a strongly collaborative research environment. G.S. Athwal and B. Gueorguiev were the most productive authors, with 11 publications each, followed by P. Raiss with 10 and J.H. Oh with 9 (Table 4). Nevertheless, productivity was widely dispersed: 2,896 authors (84.6%) contributed a single article, and only 0.7% contributed six or more. The resulting distribution was strongly right-skewed and consistent with a Lotka-type productivity pattern (Figure 4), but no small group of authors dominated the field.

Table 4. Fifteen most productive authors

Rank	Author	Articles (n)
1	Athwal GS	11
2	Gueorguiev B	11
3	Raiss P	10
4	Oh JH	9
5	Kralinger F	7
6	Quental C	7
7	Folgado J	7
8	Windolf M	7
9	Varga P	7
10	Namdari S	7
11	Abboud JA	7
12	Bicknell RT	6
13	Srikumaran U	6
14	Ritter D	6
15	Denard PJ	6

Most influential articles. The ten most-cited articles are shown in Table 5. The leading article, by Chung et al. (2011), examined factors affecting healing after arthroscopic rotator cuff repair and identified osteoporosis as an independent risk factor; it had received 388 citations. Krappinger et al. (2011) ranked second with 339 citations for their work on predicting fixation failure after proximal humerus fracture surgery. Subsequent highly cited articles addressed rotator cuff retear risk, tendon-to-bone healing, reverse shoulder arthroplasty for proximal humerus fractures, bone adaptations around short-stem implants, and radiographic assessment of proximal humeral bone quality. Collectively, the most influential studies emphasized the clinical consequences of poor bone quality rather than bone measurement alone.

Table 5. Ten most-cited articles

Rank	First author, year	Journal	Title	Citations
1	Chung SW, 2011	Am J Sports Med	Factors affecting rotator cuff healing after arthroscopic repair: osteoporosis as one of the independent risk factors	388
2	Krappinger D, 2011	Injury	Predicting failure after surgical fixation of proximal humerus fractures	339
3	Zhao J, 2021	J Shoulder Elbow Surg	Risk factors affecting rotator cuff retear after arthroscopic repair: a meta-analysis and systematic review	198

Rank	First author, year	Journal	Title	Citations
4	Bedi A, 2010	J Shoulder Elbow Surg	Diabetes mellitus impairs tendon-bone healing after rotator cuff repair	195
5	Abtahi AM, 2015	World J Orthop	Factors affecting healing after arthroscopic rotator cuff repair	193
6	Garrigues GE, 2012	Orthopedics	Hemiarthroplasty versus reverse total shoulder arthroplasty for acute proximal humerus fractures in elderly patients	191
7	Otto RJ, 2013	J Shoulder Elbow Surg	Scapular fractures after reverse shoulder arthroplasty: evaluation of risk factors and the reliability of a proposed classification	175
8	Habermeyer P, 2015	J Shoulder Elbow Surg	Midterm results of stemless shoulder arthroplasty: a prospective study	171
9	Schnetzke M, 2015	J Shoulder Elbow Surg	Radiologic bone adaptations on a cementless short-stem shoulder prosthesis	147
10	Spross C, 2015	Clin Orthop Relat Res	Deltoid tuberosity index: a simple radiographic tool to assess local bone quality in proximal humerus fractures	137

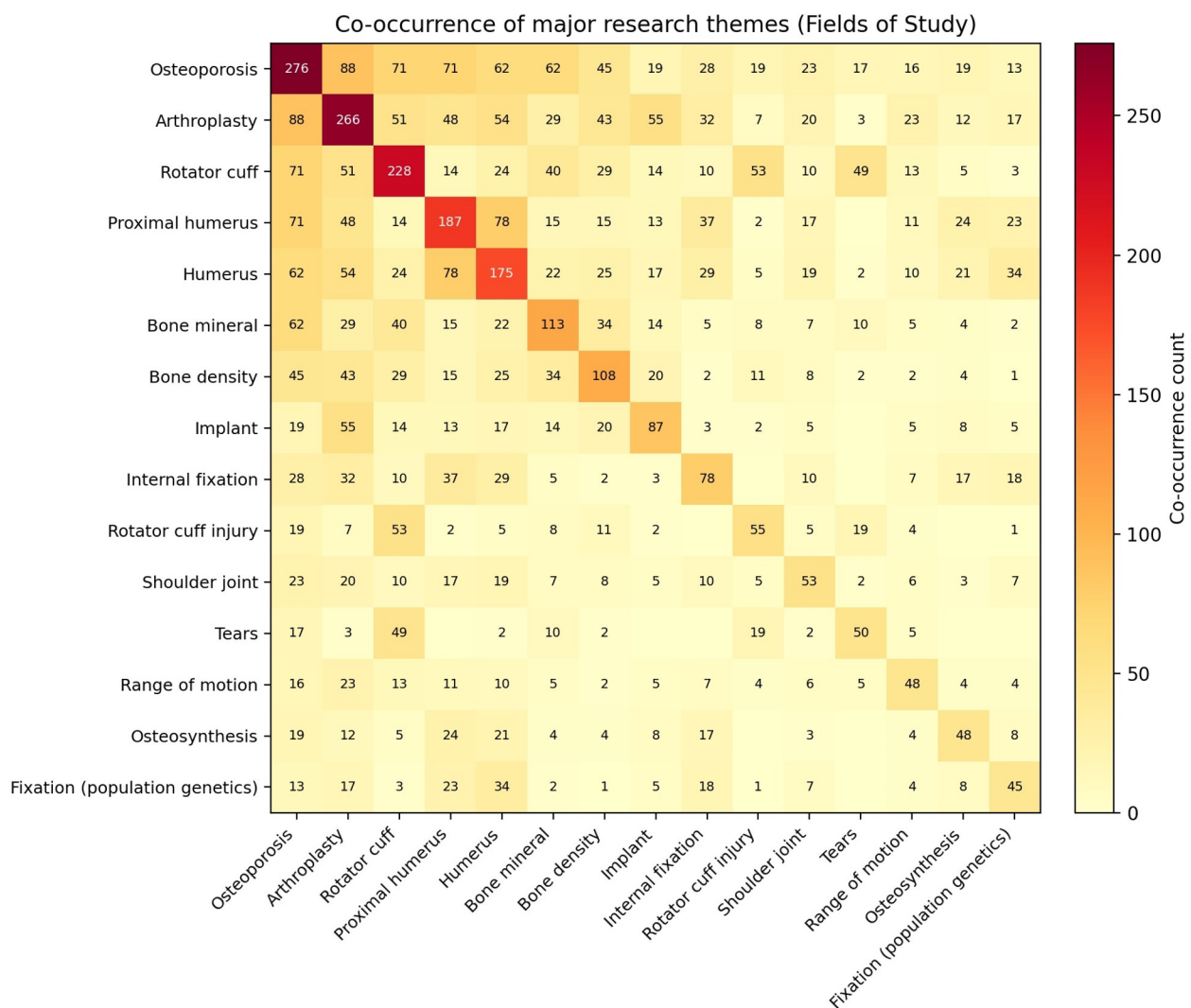


Figure 3. Co-occurrence of major database-assigned research themes after exclusion of clearly irrelevant algorithmic classifications.

Open-access trends. Overall, 52% of the publications were openly accessible. The annual open-access share increased from 12% in 2010 to 67% in 2025 and reached a peak of 77% in 2023 (Table 1), although year-to-year fluctuation was evident.

Thematic structure. After exclusion of a clearly irrelevant algorithmic field label and harmonization of closely related terms, the co-occurrence map was centered on osteoporosis, arthroplasty, rotator cuff, proximal humerus, humerus, bone mineral density, implant, and internal fixation (Figure 3). The pattern was interpreted as representing three overlapping clinical domains: soft-tissue repair, fracture fixation, and shoulder arthroplasty. Osteoporosis had the highest individual field frequency, whereas its strongest co-occurrences were with arthroplasty, rotator cuff, and proximal humerus. Arthroplasty became particularly prominent among publications from 2018 to 2025.

4. Discussion

This bibliometric analysis demonstrates substantial and sustained growth in research on osteoporosis and bone quality in shoulder surgery between 2010 and 2025. Annual output increased more than fourfold, and almost half of all publications appeared during the final five years of the study period. This trajectory suggests that bone quality has moved from a relatively specialized concern to a central variable in contemporary shoulder research. The timing of the acceleration is clinically plausible: greater use of rotator cuff repair and shoulder arthroplasty, an aging surgical population, and growing recognition of osteoporosis as a potentially modifiable perioperative risk factor have increased demand for practical methods of preoperative bone assessment.

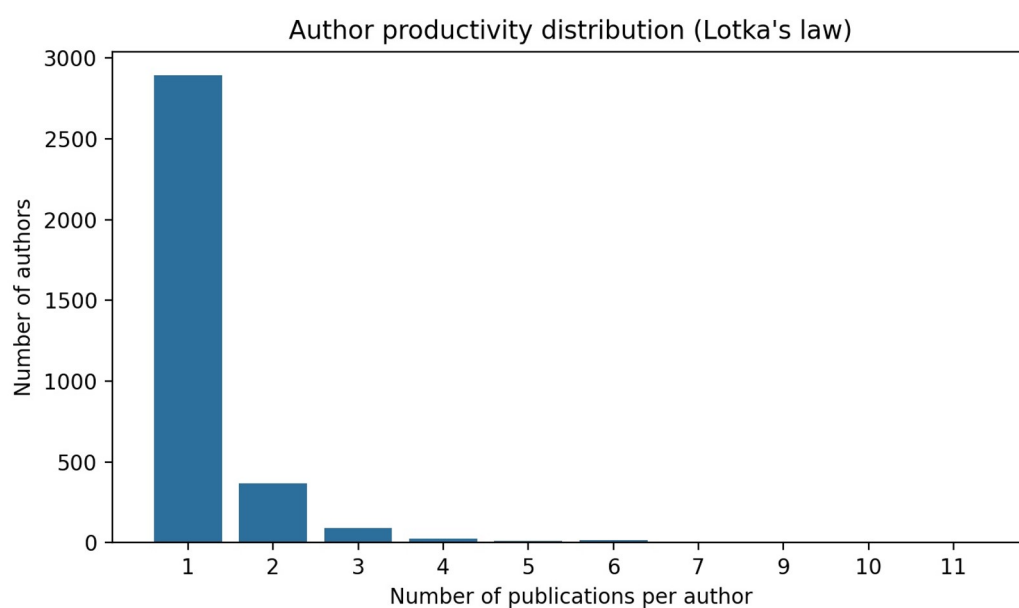


Figure 4. Distribution of the number of publications per author.

The citation profile indicates that the field's most influential work has been clinically oriented. The highest-impact articles did not merely describe osteoporosis prevalence or imaging measurements; they connected poor bone quality with tendon healing, fixation failure, retear, implant behavior, or procedure selection. The prominence of the 2011 studies by Chung et al. and Krappinger et al. explains the pronounced citation peak for that publication year and illustrates how a limited number of landmark studies can shape annual citation averages. Conversely, the low mean citation values for 2023–2025 should not

be interpreted as evidence of reduced quality or relevance, because these articles had substantially less time to accumulate citations.

The journal analysis offers practical information for both readers and investigators. The Journal of Shoulder and Elbow Surgery was the clear publication and citation hub, confirming its role as the main specialist outlet for this topic. However, the strong mean citation performance of Injury and the American Journal of Sports Medicine shows that influential work is also published outside the largest-volume source. The Bradford-type pattern further indicates that researchers can identify much of the core literature by searching a relatively small group of specialist journals, while a large peripheral zone reflects dissemination into trauma, osteoporosis, imaging, biomechanics, and general orthopaedic publications.

The author distribution reveals a broad and collaborative field rather than one controlled by a small number of repeatedly publishing investigators. More than four fifths of authors appeared only once, whereas the mean of 5.4 authors per article and the 93% multi-authorship rate point to team-based research. This structure is consistent with the multidisciplinary nature of bone-quality research, which commonly requires contributions from shoulder surgeons, trauma surgeons, musculoskeletal radiologists, biomechanical laboratories, osteoporosis specialists, and methodologists. The Lotka-type right-skew should therefore be interpreted as a descriptive productivity pattern rather than evidence of strict statistical conformity to Lotka's original law.

The thematic findings emphasize that bone quality functions as a common biological and mechanical denominator across three major areas of shoulder surgery. In rotator cuff repair, reduced local bone density can compromise anchor fixation and tendon-to-bone healing. In proximal humerus fractures, it affects screw purchase, construct stability, and the risk of fixation failure. In arthroplasty, it may influence component fixation, stress shielding, fracture risk, and the choice between stemmed, stemless, cemented, and reverse designs. The increasing prominence of arthroplasty in recent years likely reflects both rapid procedural growth and heightened interest in implant fixation in osteoporotic bone.

A further translational signal is the recurring interest in opportunistic and local bone-quality measures. Although dual-energy X-ray absorptiometry remains the reference standard for systemic osteoporosis assessment, shoulder surgeons often require site-specific information. Radiographic indices such as the deltoid tuberosity index and computed-tomography-based Hounsfield unit measurements can be obtained from images already acquired for routine care and may provide information more directly related to anchor or implant purchase. The bibliometric growth of these approaches suggests an unmet need for validated thresholds, standardized measurement regions, and prospective evidence showing that preoperative identification and treatment of poor bone quality improve surgical outcomes.

Beyond mapping research output, these findings carry practical implications for contemporary orthopaedic practice. Osteoporosis is increasingly recognized as a modifiable determinant of surgical outcome rather than an incidental comorbidity: poor bone quality compromises implant purchase, raises the risk of fixation failure and periprosthetic fracture, and influences the choice between fixation and arthroplasty. The parallel expansion of anti-osteoporotic pharmacotherapy—including bisphosphonates, denosumab, and anabolic agents such as teriparatide and romosozumab—has made perioperative bone-health optimization a realistic and increasingly routine consideration. In this context, the rising and internationally distributed research activity documented here reflects a growing shift toward integrating bone-quality assessment and treatment into preoperative planning, surgical decision-making, and postoperative care in shoulder surgery. Embedding systematic bone-health evaluation and, where indicated, targeted pharmacological

therapy into perioperative pathways may improve fixation durability and functional outcomes, and represents a priority area for future prospective and interventional research.

The study also has implications for future research. First, comparative studies should determine whether local CT- or radiograph-based measurements add predictive value beyond systemic DXA results and clinical risk scores. Second, prospective studies are needed to assess whether osteoporosis treatment before or after shoulder surgery reduces retear, fixation failure, periprosthetic fracture, or loosening. Third, reporting standards should be harmonized, because heterogeneous definitions of osteoporosis, local bone density, healing, and mechanical failure limit synthesis across studies. Finally, collaboration between clinical and biomechanical groups may help translate imaging-derived bone measures into procedure-specific decisions concerning implant type, fixation strategy, and rehabilitation.

Several limitations should be considered. The analysis used a single database, Lens.org, and its coverage, citation links, and field assignments may differ from those of Web of Science, Scopus, or PubMed. Citation counts are dynamic and favor older publications, while recent articles are disadvantaged by shorter citation windows. Restricting shoulder-related concepts to the title improved specificity but may have excluded relevant articles in which the shoulder was mentioned only in the abstract. Author-name disambiguation may be imperfect, particularly for common surnames or variations in initials. Institutional and author-country analyses could not be performed because affiliation metadata were incomplete in the export. Finally, the thematic analysis relied on algorithmically assigned fields of study. Although clearly irrelevant labels were removed and related terms were harmonized, the resulting domains should be viewed as a descriptive map rather than a formal network-clustering solution. More broadly, bibliometric indicators quantify scholarly attention and dissemination rather than methodological quality or clinical validity, so highly cited work is not necessarily the most rigorous; the search was also confined to a single set of title and abstract keywords, which may not capture every relevant study and could favor conventional terminology over emerging concepts. Despite these limitations, the study provides a reproducible overview of the growth, influence, publication structure, and major clinical themes of this literature.

5. Conclusion

Research on bone quality and osteoporosis in shoulder surgery has expanded rapidly and is concentrated in a small core of leading shoulder and sports-medicine journals. The literature is produced by a broad, highly collaborative author community. Its most influential studies link local bone quality to clinical outcomes across rotator cuff repair, proximal humerus fracture fixation, and arthroplasty. Future work is likely to focus increasingly on arthroplasty and opportunistic imaging-based assessment of local bone quality.

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