

A Bibliometric Analysis of the Most Cited Research on Humeral Avulsions of the Glenohumeral Ligament: A Paucity of High-Level Evidence



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Purpose: To identify the 25 most-cited articles on humeral avulsion of the glenohumeral ligament (HAGL) lesions and characterize them based on number of citations, citation density, source journal, year of publication, geographic origin, article type, and level of evidence. **Methods:** The Science Citation Index Expanded database was queried for all possible publications regarding HAGL lesions. The 25 most-cited articles from 1976 to 2021 relevant to the topic were selected for further analysis. Articles were characterized based on the number of citations, citation density, year of publication, source journal, country of origin, article type, article subtype, and level of evidence. **Results:** The number of citations for individual articles ranged from 21 to 182 (mean \pm standard deviation: 44.72 ± 36.87). Ten countries contributed to the 25 most cited articles, with 14 of the 25 (56%) articles published in the United States. Furthermore, the top 25 cited articles were published in 9 journals, with the majority in *Arthroscopy—The Journal of Arthroscopic and Related Surgery* ($n = 15$, 60%). There were 15 (60%) articles classified as “Clinical,” 9 (36%) as “Review/Expert Opinion,” and 1 (4%) as “Basic Science.” All clinical studies met the standard for level IV evidence. **Conclusions:** This bibliometric analysis provides a list of the 25 most cited articles related to HAGL lesions, providing a reference of impactful articles for medical educators. The lack of high level of evidence “Clinical” studies demonstrates that higher-quality research is needed to establish guidelines for the treatment and management of HAGL lesions. **Clinical Relevance:** A list of the 25 most-cited articles regarding recurrent glenohumeral instability can serve as a comprehensive reference for practitioners, educators, researchers, and orthopaedic trainees.

Glenohumeral instability is a relatively common orthopaedic issue involving a complex relationship between bony and soft tissue stabilizers of the glenohumeral joint, such as the glenoid labrum and glenohumeral ligaments.¹ In traumatic events, tears of the anteroinferior glenoid labrum, also known as

Bankart lesions, place patients at a greater risk of experiencing recurrent shoulder instability and pain after initial injury.^{1,2} Although trauma to the labrum has been implicated as a key risk factor, studies have revealed that a spectrum of concomitant injuries to other stabilizers may also contribute to recurrent shoulder instability.^{1,3}

Humeral avulsion of the glenohumeral ligament (HAGL), referring to a capsular rupture of the inferior glenohumeral ligament off the humeral attachment site, has been reported to occur in 9% of patients with shoulder instability.^{3,4} Biomechanically, HAGL lesions occur during anterior shoulder dislocation when the humerus is abducted and externally rotated.⁵ HAGL lesions often occur concomitantly with other injuries causing shoulder instability but, in rare cases, may also present as an isolated injury.⁶ Given that the glenohumeral ligaments are the main static stabilizers of the shoulder joint throughout its range of motion, a HAGL lesion may chronically impair shoulder stability despite successful surgical repair of concomitant injuries.¹ Although the prevalence of HAGL lesions is relatively

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low, this observation may partly be attributed to the difficulty of accurately diagnosing this injury, especially in the setting of other concurrent glenohumeral injuries.^{7,8} Untreated HAGL injuries are often found using magnetic resonance imaging (MRI) when patients with history of surgically repaired Bankart lesions, Hill-Sachs defects, or rotator cuff tears present with unexplained chronic shoulder instability.⁵ As a result, knowledge regarding the thorough diagnosis and proper treatment of HAGL lesions is essential to prevent recurrent anterior instability and pain, development of posttraumatic osteoarthritis, and failure of isolated Bankart repair.^{7,8}

Citation impact, or the number of times a publication has been cited, is one of many indicators describing the scientific relevance of an article.⁹ Analyses of the most-cited publications have been conducted in various fields of orthopaedic subspecialties, including arthroplasty, arthroscopy, and sports injuries.^{10,11} Studies characterizing the most cited articles regarding a specific condition can serve as a tool for educators and trainees to appreciate the historical evolution of our understanding of a topic and elucidate a range of treatment strategies.¹⁰ Reviews of the most cited articles related to a particular topic organize high-impact articles, which may assist practitioners when referencing that topic. A detailed analysis of the most cited articles concerning HAGL lesions can be useful in comprehensively identifying areas for potential research needs to optimize the understanding of this essential pathology, therefore providing a framework to help improve treatment modalities for recurrent glenohumeral instability. The purposes of this study were to identify the 25 most-cited articles on HAGL lesions and to characterize them based on the number of citations, citation density, source journal, year of publication, geographic origin, article type, and level of evidence. The hypothesis of the study was that the number of citations would reflect the relatively low reported rates of HAGL lesions and that current literature in the field would contain a low level of evidence.

Methods

Similar to previous bibliometric studies, a systematic query of the Science Citation Expanded Database (Clarivate) was performed to identify articles focused on HAGL lesions.¹¹⁻¹⁵ The literature search was conducted on November 6, 2022, including all journals listed in the Web of Science categories of "Orthopedics" and "Sports Medicine" from 1976 to 2021. The following search terms were used: "HAGL," "humeral avulsion of the glenohumeral ligament," "posterior humeral avulsion of the glenohumeral ligament injury," "HAGL lesion," "HAGL injury," "HAGL repair," "HAGL injuries," "humeral avulsion of the glenohumeral ligament injuries," "humeral avulsion of the glenohumeral ligament injury," and "humeral avulsion

of the glenohumeral ligament repair." Through this methodology, 101 articles were initially identified. The resulting articles were sorted by the total number of citations for each. In cases where 2 or more articles had the same total number of citations, the article's citation density (total number of citations divided by number of years since publishing) was used as a tiebreaker. Subsequently, full articles were individually reviewed to ensure their pertinence to HAGL lesions, isolating only articles that contained discussion of HAGL lesions in a clinically meaningful way ($n = 59$). Of these, the 25 most-cited articles were then selected for further analysis.

Data regarding the total number of citations, citation density, year of publication, source journal, and country of origin were extracted for each manuscript and recorded in Microsoft Excel (Version 16.0, Redmond, WA). The top 25 cited articles were further characterized as "Basic Science," "Review/Expert Opinion," or "Clinical." "Basic Science" articles included anatomic, cadaveric, and biomechanical studies performed in a controlled laboratory setting. "Review/Expert Opinion" articles included systematic reviews, non-systematic reviews, and surgical technique manuscripts. Clinical articles were additionally characterized as "Therapeutic," "Prognostic," or "Diagnostic" according to *The Journal of Bone & Joint Surgery* guidelines.¹⁶ In addition, the level of evidence (I, II, III, IV, V) of clinical articles was evaluated according the aforementioned guidelines.¹⁶ All data were further analyzed in Microsoft Excel (Version 16.0, Redmond, WA).

Results

The 25 most-cited publications on the topic of HAGL lesions were cited 1,118 times in total. [Table 1](#) shows the 10 most-cited articles, along with their respective total number of citations and citation densities. All 25 most-cited articles can be found in Supplement 1. The number of citations for individual articles ranged from 21 to 182 (mean 44.72; standard deviation ± 36.87), and citation densities ranged from 1 to 6.74 (mean 2.64; standard deviation ± 1.51). Of the publications included in this study, the article "Humeral Avulsion of Glenohumeral Ligaments as a Cause of Anterior Shoulder Instability" by Wolf et al.¹⁷ had the highest number of citations (182) and highest citation density (6.74) at the time the search was performed. The second and third most-cited articles were written by Larrain et al.¹⁸ ("Arthroscopic Management of Traumatic Anterior Shoulder Instability in Collision Athletes: Analysis of 204 Cases With a 4- to 9-Year Follow-Up and Results With the Suture Anchor Technique" *Arthroscopy*, 2006; number of citations, 100) and Bokor et al.¹⁹ ("Anterior Instability of the Glenohumeral Joint With Humeral Avulsion of the Glenohumeral Ligament" *JBJS Br*, 1999; number of citations, 93). The

Table 1. The 10 Most Cited Articles Related to HAGL Lesions

Rank	Article	Number of Citations	Citation Density
1	Wolf EM, Cheng JC, Dickson K. Humeral avulsion of glenohumeral ligaments as a cause of anterior shoulder instability. <i>Arthroscopy</i> 1995;11:600-607.	182	6.74
2	Larrain MV, Montenegro HJ, Mauas DM, Collazo CC, Pavón F. Arthroscopic management of traumatic anterior shoulder instability in collision athletes: Analysis of 204 cases with a 4- to 9-year follow-up and results with the suture anchor technique. <i>Arthroscopy</i> 2006;22:1283-1289.	100	6.25
3	Bokor DJ, Conboy VB, Olson C. Anterior instability of the glenohumeral joint with humeral avulsion of the glenohumeral ligament. <i>J Bone Joint Surg Br</i> 1999;81-B(1):93-96.	93	4.04
4	Field LD, Bokor DJ, Savoie FH. Humeral and glenoid detachment of the anterior inferior glenohumeral ligament: A cause of anterior shoulder instability. <i>J Shoulder Elbow Surg</i> 1997;6:6-10.	82	3.28
5	Bui-Mansfield LT, Banks KP, Taylor DC. Humeral avulsion of the glenohumeral ligaments: The HAGL lesion. <i>Am J Sports Med</i> 2007;35:1960-1966.	66	4.40
6	Warner JJP, Beim GM. Combined Bankart and HAGL lesion associated with anterior shoulder instability. <i>Arthroscopy</i> 1997;13:749-752.	59	2.36
7	Oberlander MA, Morgan BE, Visotsky JL. The BHAGL lesion: A new variant of anterior shoulder instability. <i>Arthroscopy</i> 1996;12:627-633.	48	1.85
8	Arciero RA, Mazzocca AD. Mini-open repair technique of HAGL (humeral avulsion of the glenohumeral ligament) lesion. <i>Arthroscopy</i> 2005;21(9):1152.e1-1152.e4.	46	2.71
9	Richards DP, Burkhart SS. Arthroscopic humeral avulsion of the glenohumeral ligaments (HAGL) repair. <i>Arthroscopy</i> 2004;20:134-141.	36	2.00
10	Castagna A, Snyder SJ, Conti M, Borroni M, Massazza G, Garofalo R. Posterior humeral avulsion of the glenohumeral ligament: A clinical review of 9 cases. <i>Arthroscopy</i> 2007;23:809-815.	35	2.33

HAGL, humeral avulsion of the glenohumeral ligament.

articles with the second- and third-highest citation density were written by Larrain et al.¹⁸ ("Arthroscopic Management of Traumatic Anterior Shoulder Instability in Collision Athletes: Analysis of 204 Cases With a 4- to 9-Year Follow-Up and Results With the Suture Anchor Technique" *Arthroscopy*, 2006; citation density, 6.25) and Bui Mansfield et al.⁶ ("Humeral Avulsion of the Glenohumeral Ligaments: The HAGL Lesion" *AJSM*, 2007; citation density, 4.40).

The top 25 articles were published in 9 different journals, listed in Table 2. The journals that published the greatest number of articles were *Arthroscopy—The Journal of Arthroscopic and Related Surgery* (n = 15, 60%), followed by *Journal of Shoulder and Elbow Surgery* (n = 2, 8%) and *Skeletal Radiology* (n = 2, 8%). Figure 1 shows the top 25 articles by year

published. Of the included articles, the earliest year of publication was 1995, and the most recent year of publication was 2016. The greatest number of articles was published in 2007 (n = 4). The top 25-cited articles came from 10 countries of origin, shown in Table 3. The majority were published in the United States (n = 14, 56%).

There were 15 articles (60%) classified as "Clinical," 9 articles (36%) as "Review/Expert Opinion," and 1 article (4%) as "Basic Science." The majority of the clinical articles were subclassified as "Clinical-Therapeutic" (11/15, 73.3%). Three articles were subclassified as "Clinical-Prognostic" (20.0%) and 1 as "Clinical-Diagnostic" (6.7%). All clinical articles met the standard for Level IV evidence, and no studies presented Level I, II, III, or V evidence.

Table 2. Journals in Which the Top 25 HAGL Lesion Articles Were Published

Journal	Number of Articles	% of Articles
<i>Arthroscopy—The Journal of Arthroscopic and Related Surgery</i>	15	60%
<i>Journal of Shoulder and Elbow Surgery</i>	2	8%
<i>Skeletal Radiology</i>	2	8%
<i>Journal of Bone and Joint Surgery—British Volume</i>	1	4%
<i>American Journal of Sports Medicine</i>	1	4%
<i>Journal of the American Academy of Orthopaedic Surgeons</i>	1	4%
<i>Orthopedic Clinics of North America</i>	1	4%
<i>Scandinavian Journal of Medicine & Science in Sports</i>	1	4%
<i>Journal of Bone and Joint Surgery—American Volume</i>	1	4%

HAGL, humeral avulsion of the glenohumeral ligament.

Number of Articles Published per Year

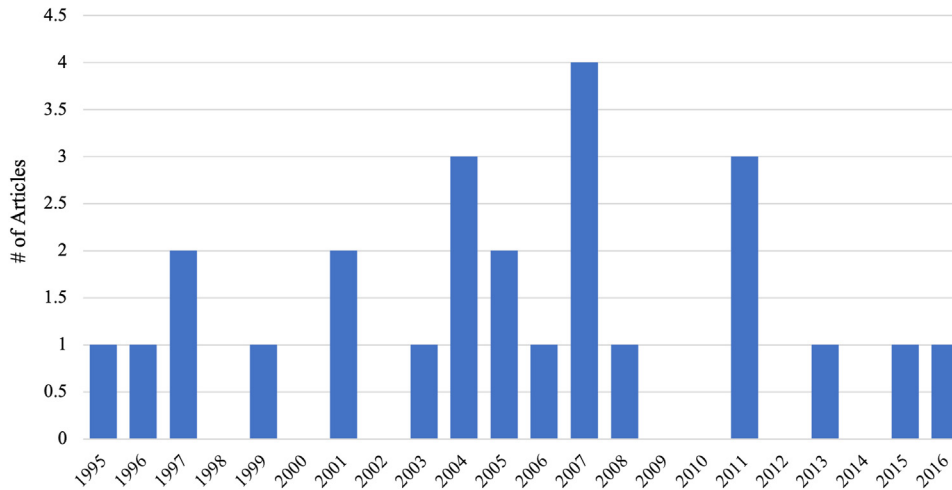


Fig 1. Top 25 HAGL lesion articles by year published.

Discussion

The current study identified the 25 most cited articles related to HAGL lesions with a total of 1,118 citations. The most-cited article (182 citations) and the article with the highest citation density (6.74 citations per year) was “Humeral Avulsion of Glenohumeral Ligaments as a Cause of Anterior Shoulder Instability” by Wolf et al.¹⁷ *Arthroscopy* published the greatest number of articles included in the study ($n = 15$ [60%]), with the *Journal of Shoulder and Elbow Surgery* ($n = 2$ [8%]) and *Skeletal Radiology* ($n = 2$ [8%]) publishing the second most. The United States led all countries in the number of articles published ($n = 14$ [56%]), whereas the United Kingdom and Italy were tied for second ($n = 2$ [8%]). All clinical articles ($n = 15$ [60%]) presented Level IV evidence. This comprehensive synthesis of research is a useful guide for practitioners to reference when searching for highly cited articles related to HAGL lesions. Given the relatively low levels of evidence provided in these most commonly cited articles, there is a need for higher-quality clinical research focused on HAGL lesions.

The importance of diagnosis and management of HAGL lesions in the evaluation and treatment of patients with glenohumeral instability cannot be underappreciated. As the most important anterior static stabilizer of the shoulder, tears of the inferior glenohumeral ligament (IGHL) from the humeral attachment site should be treated in an open or arthroscopic fashion during instability surgery to prevent recurrent instability.^{5,19} As described by O’Brien et al.,²⁰ the IGHL complex with both its anterior and posterior bands acts as a hammock supporting the humeral head in its position while the humerus is abducted. Mechanically, the anterior and posterior bands act as independent cables, tensioning and loosening together through the range of glenohumeral motion. If either is disrupted, the

glenohumeral contact points can shift, altering forces across the joint and predisposing it to instability.²¹ These biomechanical principles underscore the importance of effectively addressing HAGL lesions surgically in cases of instability. Thus the optimal means of diagnosis and management must be well understood by orthopaedists.

As previously stated, the work of Wolf et al.¹⁷ in 1995 was the most cited article (182 citations) and the article with the highest citation density (6.74 citations per year). The 10 most-cited articles were each cited at least 35 times. Compared to similar studies on other orthopaedic shoulder topics such as shoulder arthroplasty or rotator cuff tears, the number of citations for HAGL lesions is much lower. Mercurio et al.¹⁰ examined the 50 most-cited shoulder arthroplasty articles and determined that the top 10 articles were cited at least 118 times each, with the top article having 797 citations. Furthermore, in the Familiari et al.²² investigation of the 50 most-cited rotator cuff tear articles, the top article was cited 1558 times, whereas the top 10 articles all had at least 633 citations. The lower number of

Table 3. Countries of Origin for the Top 25 HAGL Lesion Articles

Country of Origin	Number of Articles	% of Articles
United States	14	56%
United Kingdom	2	8%
Italy	2	8%
Argentina	1	4%
Japan	1	4%
Norway	1	4%
Canada	1	4%
South Korea	1	4%
Austria	1	4%
Australia	1	4%

HAGL, humeral avulsion of the glenohumeral ligament.

citations in HAGL lesion research is attributed to the relatively new appreciation for this clinical entity, as well as the relatively uncommon nature of this pathology, with HAGL lesions identified during only 3.1% of shoulder arthroscopies.⁴

The clinical articles ($n = 15$ [60%]) pertaining to HAGL lesions identified by our study all displayed Level IV evidence. Similarly, Mercurio et al.¹⁰ found that the majority (72%, 31/43) of clinical articles out of the top 50 cited shoulder arthroplasty articles displayed Level IV evidence. In evaluating the top 50 most-cited rotator cuff tear articles, Familiari et al.²² also found that the majority (63%, 31/46) of clinical articles presented Level IV evidence. Thus it is important for readers and researchers alike to understand the limitations of the relatively low-quality evidence presented in the most highly-cited articles related to HAGL lesions and to work towards improving evidence with high-quality studies whenever possible.

In the article by Wolf et al.,¹⁷ the most-cited article found by our review, the authors arthroscopically examined 64 shoulders diagnosed with anterior instability. HAGL lesions were present in 9.3% of shoulders, whereas laxity was present in 17.2% and Bankart lesions in 73.5%. A single traumatic episode caused HAGL lesions in all patients. Nonoperative treatment was unsuccessful, with multiple recurrences of instability, but surgical reattachment of the glenohumeral ligament to its humeral insertion (2 open, 4 arthroscopic) led to no reported disability or instability recurrence at final follow-up. In patients experiencing anterior shoulder instability and lacking a Bankart lesion, HAGL lesions should be the main focus of diagnosis and management. On arthroscopic evaluation, a torn anterior band of the IGHL and thus an exposed subscapularis in the area indicates a potential HAGL lesion.

The 2006 work of Larrain et al.,¹⁸ with the second-most citations, retrospectively analyzed 204 cases of recurrent or acute traumatic anterior instability in rugby players who were initially arthroscopically examined. Only 4 cases of HAGL lesions were found in the entire sample; 3 caused recurrent instability, whereas 1 caused acute instability. All 4 HAGL lesions were repaired using mini-open reattachment surgery. Bankart lesions, however, were found in 184 shoulders, 36 of which caused acute instability, and 148 caused recurrent instability. Recurrent instability necessitated open surgery significantly more often than an acute instability episode. By including HAGL lesions in their exclusion criteria for arthroscopic reconstruction, Larrain et al.¹⁸ were able to achieve good or excellent results (using the Rowe scale) for >90% of patients. The authors therefore concluded that exclusion criteria for arthroscopic reconstruction in contact sports players should include HAGL lesions.

The third-most cited article, written by Bokor et al.¹⁹ in 1999, retrospectively analyzed 547 patients who underwent operations for shoulder instability. HAGL lesions were deemed the cause of instability in 41 shoulders (7.5%). Most HAGL lesions (85.4%) were discovered during initial exploration, whereas the remaining lesions (14.6%) were found during revision of a previous procedure. Regardless of the time of discovery, patients with HAGL lesions were older on average when compared with other patients with shoulder instability. Similar to the findings of Wolf et al.¹⁷ in 1996, violent injury leading to dislocation caused the majority (94.3%) of primary cases of HAGL lesions. Damage to the rotator cuff was noted in 17.4% of primary cases, whereas a Bankart lesion was documented in 11.4% of primary cases. The group with the greatest incidence (39%) of HAGL lesions was patients who experienced a violent injury causing dislocation and did not have multidirectional laxity or a Bankart lesion.

The United States published the majority ($n = 14$ [56%]) of the 25 most cited HAGL lesion articles. Nine other countries published at least 1 article, with the United Kingdom and Italy ($n = 2$ [8%]) publishing the second-most articles. Articles that analyzed the top 50 most-cited articles on shoulder arthroplasty and rotator cuff tears also determined that the United States published the most articles out of all countries.^{10,22} Despite examining fewer articles, HAGL lesion articles represented a similar number of countries ($n = 10$) when compared to articles on shoulder arthroplasty ($n = 9$) and rotator cuff tears ($n = 8$).^{10,22} In the future, international research and multicenter collaboration on research related to HAGL lesions, including their diagnosis, fixation strategies, and treatment outcomes, will continue to be of importance to improve our understanding of this previously underappreciated entity.

Limitations

There are several limitations in this study. The articles included were evaluated solely based on quantitative measures, so the quality of articles was not assessed. The measurements in this study are time-sensitive, so newer impactful articles with low cumulative citations were not included. Furthermore, articles published after this study was conducted may fall within the inclusion criteria. However, the majority of articles ($n = 23$ [92%]) were published before 2015, so the likelihood of this is low. The Science Citation Expanded Database was the only database used for the evaluation of articles. Therefore articles from different sources, such as oral lectures, textbooks, digital media, and non-indexed journals, were not included in our analysis. Because citation number and density were the only measures of impact, this study cannot be considered to be completely comprehensive. Additionally, the

authors manually reviewed all search results to identify articles that discussed HAGL lesions meaningfully. However, there is a degree of subjectivity in determining what constitutes meaningful/substantial discussion of these lesions. As such, articles that some may consider to be relevant may not have been included in this analysis.

Conclusion

This bibliometric analysis provides a list of the 25 most-cited articles related to HAGL lesions, providing a reference of impactful articles for medical educators. The lack of high-level-of-evidence “Clinical” studies demonstrates that higher-quality research is needed to establish guidelines for the treatment and management of HAGL lesions.

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