SCOPING REVIEW

Acromioclavicular Joint Injury: A Bibliometric Analysis of the 50 Most Cited Articles

Grace L. Basralian, BS; Paxton Sweeney, BA; Daniel Calem, MD; Eitan Kohan, MD

Research performed at Hackensack Meridian Health, Department of Orthopedic Surgery, Hackensack, USA

Received: 17 September 2024 *Accepted: 28 December 2024*

Abstract

Objectives: This study aims to identify the 50 most influential articles on acromioclavicular (AC) joint injury, exploring research trends and treatment options.

Methods: Utilizing the Scopus database, the 50 top-cited articles were selected based on predefined criteria and analyzed for bibliometrics, including authorship, journal, and evidence level.

Results: From 1963 to 2021, these articles amassed 3,363 citations, primarily comprising case series with level IV evidence, published across 19 journals from eight countries.

Conclusion: This review highlights the dynamic progression in AC joint injury management and signals the urgent need for advanced research to enhance clinical decision-making and evidence-based practices.

Level of evidence: V

Keywords: Acromioclavicular joint, Acromioclavicular joint treatment, Bibliometric analysis, Shoulder

Introduction

Acromioclavicular (AC) joint separation is a common injury in athletes, especially in the young adult population.[1] The overall prevalence of AC injuries is 1.8 per 100 per year.[2] Men between the ages of 20 to 39 years old are 8.5 times more likely to suffer this type of injury when compared to women.[2] The typical mechanism of injury is a direct force to the adducted shoulder, often during contact sport or from a fall directly onto the lateral shoulder. The severity of the injury depends on the amplitude of force and is categorized via the Rockwood Classification (I through V).[3] Type I and II injuries are usually managed nonoperatively, whereas some type III and most type IV, V, and VI injuries are indicated for surgical intervention.[3]

The management of AC joint injuries has undergone significant evolution, prompting a need for a comprehensive understanding of the indications, techniques, expected outcomes, and complications for each treatment option. There are several reconstruction techniques available but they all typically involve reduction of the AC joint and reconstruction of the coracoclavicular (CC) ligaments, however, there is still no gold standard for the treatment of AC joint injuries.[3] There are many surgical techniques that can be utilized for this injury, many of which are physician-dependent. Some current surgical techniques being utilized for Type III or higher injuries are the anatomic coracoclavicular ligament reconstruction (ACCR) using autograft or allograft tendon to replicate the CC ligaments and Coracoacromial ligament (CAL) transfer.[4] These are generally utilized in "acute" settings, typically defined as less than 3 weeks after the injury, or for chronic injuries where conservative measures have failed.[4,5] The goals of these interventions depend on the setting in which they are used. For acute settings, surgical intervention is aimed at restoring joint stability and range of motion. For those where conservative measures have already failed, the goal of surgery is to reduce chronic pain and scapular dyskinesis.[5] Complications of surgical reconstruction include fixation failure, clavicle fracture, stiffness, shoulder pain, infection, and increased development of secondary AC joint disease.[6] With a varying amount of reported postoperative complications in the existing literature, it is difficult to say definitively that all patients benefit from surgery and this discrepancy needs to be discussed when

Corresponding Author: Paxton Sweeney, Hackensack Meridian Health, Department of Orthopedic Surgery, NJ, USA

Email: Paxton.sweeney@hmhn.org

THE ONLINE VERSION OF THIS ARTICLE ABJS.MUMS.AC.IR

considering surgical intervention.[6]

Bibliometric analyses have been conducted in different realms of orthopedics such as pediatrics, arthroplasty, and orthopedic oncology.[7–9] assessing the true impact of individual studies is challenging. Citation count is a simple but reliable metric to quantify the frequency with which peers have credited a study and thus relevance within its designated topic of interest. A bibliometric analysis relies on this metric to highlight past and current trends and trace the overall development of a scientific topic over time. No bibliometric analyses to date have been conducted on AC joint injury. The purpose of this study was to (1) identify the 50 most cited articles on the topic of AC joint injury (2) examine the demographic and bibliometric characteristics of these articles and (3) provide a comprehensive picture of the global trends in surgical indications, techniques, and complications of this condition.

Materials and Methods

Institutional review board (IRB) approval was not necessary for the completion of this study. In December of 2023, Elsevier's Scopus Citation Database was utilized to identify articles on acromioclavicular joint separations and injuries. Data was collected on four separate dates within December, however, the citation rank of articles reviewed was checked to ensure no changes had occurred between data collection dates. A Boolean search using the terms, ("Acromioclavicular AND Joint AND Separation" AND "Acromioclavicular AND Joint AND Dislocation" AND "Acromioclavicular AND Joint AND Injury" was used.

The articles retrieved through the search were arranged in descending order based on the number of citations they received. Following this, publication titles and abstracts were examined to identify studies focusing primarily on acromioclavicular joint separations, dislocations, and injuries. The remaining articles were then assessed for eligibility. Primary publications addressing acromioclavicular joint injury outcomes, indications, techniques, procedural details, and complications were included. Biomechanical analyses, cadaveric studies, narrative review articles, systematic reviews, and meta-analyses were excluded. Studies not published in English were also excluded. 51 articles were excluded using this criterion, including one because it was written in German, seven because it was not related to the topic, six because they could not be accessed, and 37 because they fell under article types listed in the exclusion criteria. Out of these, four were radiographic studies, one was cadaveric, two were technical notes, two were controlled lab studies, and the last 28 were review articles. Review articles were excluded because they were not primary sources of information for this topic.

The top 50 most cited articles were further examined. Bibliometric data including publication year, authorship, publishing journal, country of origin, study type, and level of evidence determined according to The Journal of Bone and Joint Surgery guidelines were collected.[10] The data were presented in terms of total citations and the yearly distribution of published articles. Additionally, citation density was computed for each analyzed article, defined as the total number of citations divided by the number of years since the article's publication.

Results

The initial article search yielded 253 documents. The top 101 articles listed in descending order of most citations were screened to produce the final set of 50 publications. Tables were made comparing the date each paper was published, study type, country of origin, and level of evidence [Figure 1].

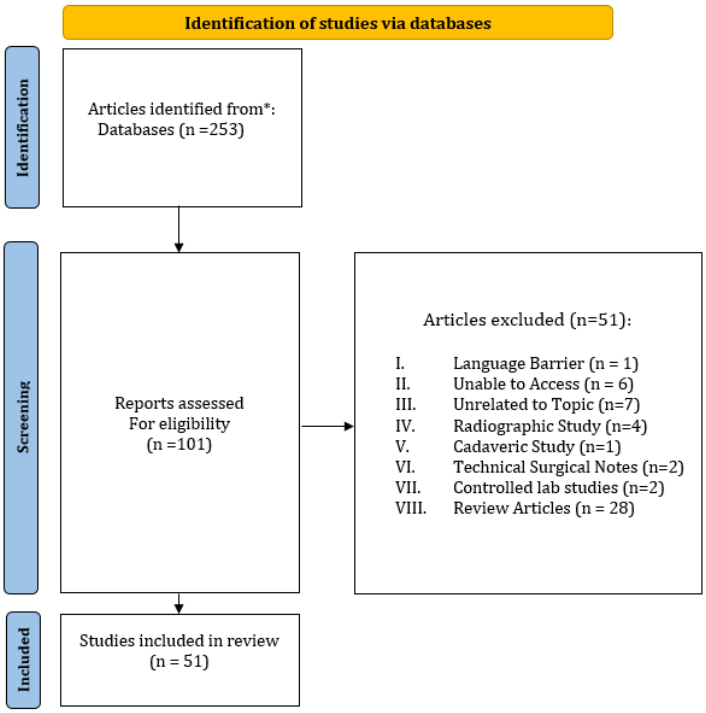

Figure 1. Modified PRISMA (Preferred Reporting for Systematic Reviews and Meta-analyses) Flowchart

The top 50 most cited articles were published between 1963 and 2021, with the year 2013 having the most publications with a total of 6. There was a 3-year span from 2012 to 2014 with 13 publications [Figure 2]. The total number of citations for the top 50 articles was 3,363. The article with the most citations, *Scheibel et el* had 300 citations.[11] The range of citations was between 17 and 300. The average number of citations was 67.26 [Table 1].[11–14,14–19,19–58] The year 1995 had the most citations at 357 between 4 separate articles. The least amount of citations occurred in 1996, where one article yielded 24 [Figure 2].

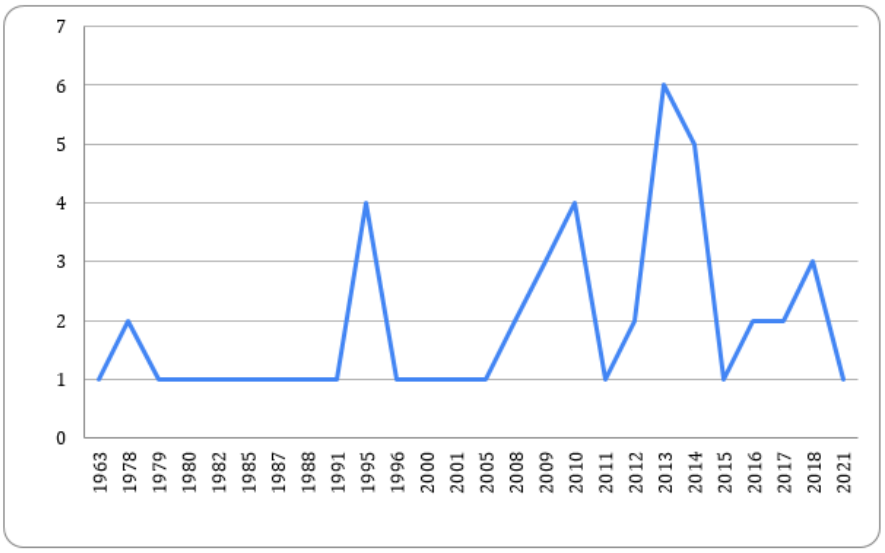

Figure 2. Articles by Year

Table 1. 50 Most Cited Articles on Acromioclavicular Joint Injury

Rank	Article Citation	Number of Citations (Citation Density)	Level of Evidence
1	Scheibel, Markus, Silvia Dröschel, Christian Gerhardt, and Natascha Kraus. "Arthroscopically Assisted Stabilization of Acute High-Grade Acromioclavicular Joint Separations." The American Journal of Sports Medicine 39, no. 7 (July 2011): 1507–16. https://doi.org/10.1177/0363546511399379.	300 (25)	IV
2	Kaplan, Lee D., David C. Flanigan, John Norwig, Patrick Jost, and James Bradley. "Prevalence and Variance of Shoulder Injuries in Elite Collegiate Football Players." The American Journal of Sports Medicine 33, no. 8 (August 2005): 1142–46. https://doi.org/10.1177/0363546505274718.	256 (14.22)	III
3	Salzmann, Gian M., Lars Walz, Stefan Buchmann, Prapagorn Glabgly, Arne Venjakob, and Andreas B. Imhoff. "Arthroscopically Assisted 2-Bundle Anatomical Reduction of Acute Acromioclavicular Joint Separations." The American Journal of Sports Medicine 38, no. 6 (June 2010): 1179–87. https://doi.org/10.1177/0363546509355645.	199 (15.31)	IV
4	Black, G. B., J. A. McPherson, and M. H. Reed. "Traumatic Pseudodislocation of the Acromioclavicular Joint in Children. A Fifteen Year Review." The American Journal of Sports Medicine 19, no. 6 (1991): 644–46. https://doi.org/10.1177/036354659101900616.	172 (15.64)	IV
5	Sim, E., N. Schwarz, K. Höcker, and A. Berzlanovich. "Repair of Complete Acromioclavicular Separations Using the Acromioclavicular-Hook Plate." Clinical Orthopaedics and Related Research, no. 314 (May 1995): 134–42.	153 (5.46)	IV
6	Tischer, Thomas, Gian Max Salzmann, Hosam El-Azab, Stephan Vogt, and Andreas B. Imhoff. "Incidence of Associated Injuries with Acute Acromioclavicular Joint Dislocations Types III through V." The American Journal of Sports Medicine 37, no. 1 (January 2009): 136–39. https://doi.org/10.1177/0363546508322891.	145 (10.36)	IV
7	Galpin, R. D., R. J. Hawkins, and R. W. Grainger. "A Comparative Analysis of Operative versus Nonoperative Treatment of Grade III Acromioclavicular Separations." Clinical Orthopaedics and Related Research, no. 193 (March 1985): 150–55.	145 (3.82)	III

Table 1. Continued

8	Schlegel, T. F., R. T. Burks, R. L. Marcus, and H. K. Dunn. "A Prospective Evaluation of Untreated Acute Grade III Acromioclavicular Separations." The American Journal of Sports Medicine 29, no. 6 (2001): 699–703.	128 (5.82)	III
9	Jensen, Gunnar, Jan Christoph Katthagen, Laura Esther Alvarado, Helmut Lill, and Christine Voigt. "Has the Arthroscopically Assisted Reduction of Acute AC Joint Separations with the Double Tight-Rope Technique Advantages over the Clavicular Hook Plate Fixation?" Knee Surgery, Sports Traumatology, Arthroscopy: Official Journal of the ESSKA 22, no. 2 (February 2014): 422–30. https://doi.org/10.1007/s00167-012-2270-5.	115 (12.78)	III
10	Morrison, D. S., and M. J. Lemos. "Acromioclavicular Separation. Reconstruction Using Synthetic Loop Augmentation." The American Journal of Sports Medicine 23, no. 1 (1995): 105–10. https://doi.org/10.1177/036354659502300118.	112 (4.15)	IV
11	Venjakob, Arne J., Gian M. Salzmann, Florian Gabel, Stefan Buchmann, Lars Walz, Jeffrey T. Spang, Stephan Vogt, and Andreas B. Imhoff. "Arthroscopically Assisted 2-Bundle Anatomic Reduction of Acute Acromioclavicular Joint Separations: 58-Month Findings." The American Journal of Sports Medicine 41, no. 3 (March 2013): 615–21. https://doi.org/10.1177/0363546512473438.	111 (11.1)	IV
12	Pauly, Stephan, Christian Gerhardt, Norbert P. Haas, and Markus Scheibel. "Prevalence of Concomitant Intraarticular Lesions in Patients Treated Operatively for High-Grade Acromioclavicular Joint Separations." Knee Surgery, Sports Traumatology, Arthroscopy: Official Journal of the ESSKA 17, no. 5 (May 2009): 513–17. https://doi.org/10.1007/s00167-008-0666-z.	86 (6.14)	IV
13	Yoo, Jae-Chul, Jin-Hwan Ahn, Jung-Ro Yoon, and Jae-Hyuk Yang. "Clinical Results of Single-Tunnel Coracoclavicular Ligament Reconstruction Using Autogenous Semitendinosus Tendon." The American Journal of Sports Medicine 38, no. 5 (May 2010): 950–57. https://doi.org/10.1177/0363546509356976.	83 (6.38)	IV
14	Pauly, Stephan, Natascha Kraus, Stefan Greiner, and Markus Scheibel. "Prevalence and Pattern of Glenohumeral Injuries among Acute High-Grade Acromioclavicular Joint Instabilities." Journal of Shoulder and Elbow Surgery 22, no. 6 (June 2013): 760–66. https://doi.org/10.1016/j.jse.2012.08.016.	65 (6.50)	II
15	Hessmann, M., L. Gotzen, and H. Gehling. "Acromioclavicular Reconstruction Augmented with Polydioxanonsulphate Bands. Surgical Technique and Results." The American Journal of Sports Medicine 23, no. 5 (1995): 552–56. https://doi.org/10.1177/036354659502300506.	64 (2.37)	II
16	MacDonald, P. B., M. J. Alexander, J. Frejuk, and G. E. Johnson. "Comprehensive Functional Analysis of Shoulders Following Complete Acromioclavicular Separation." The American Journal of Sports Medicine 16, no. 5 (1988): 475–80. https://doi.org/10.1177/036354658801600508.	64 (1.88)	II
17	Lancaster S, Horowitz M, Alonso J. Complete acromioclavicular separations. A comparison of operative methods. Clin Orthop Relat Res. 1987 Mar ;(216):80-88. PMID: 3815974.	62 (1.77)	III
18	Leidel, Bernd A., Volker Braunstein, Chlodwig Kirchhoff, Susann Pilotto, Wolf Mutschler, and Peter Biberthaler. "Consistency of Long-Term Outcome of Acute Rockwood Grade III Acromioclavicular Joint Separations after K-Wire Transfixation." The Journal of Trauma 66, no. 6 (June 2009): 1666–71. https://doi.org/10.1097/TA.0b013e31818c1455.	61 (4.36)	II
19	Tomlinson, Daniel P., David W. Altchek, Jeffrey Davila, and Frank A. Cordasco. "A Modified Technique of Arthroscopically Assisted AC Joint Reconstruction and Preliminary Results." Clinical Orthopaedics and Related Research 466, no. 3 (March 2008): 639–45. https://doi.org/10.1007/s11999-007-0085-3.	57 (3.8)	IV
20	Bargren, J. H., S. Erlanger, and H. M. Dick. "Biomechanics and Comparison of Two Operative Methods of Treatment of Complete Acromioclavicular Separation." Clinical Orthopaedics and Related Research, no. 130 (1978): 267–72.	52 (1.18)	II
21	Park, J. P., J. A. Arnold, T. P. Coker, W. D. Harris, and D. A. Becker. "Treatment of Acromioclavicular Separations. A Retrospective Study." The American Journal of Sports Medicine 8, no. 4 (1980): 251–56. https://doi.org/10.1177/036354658000800407.	51 (1.19)	III
22	Stein, Thomas, Daniel Müller, Marc Blank, Yana Reinig, Tim Saier, Reinhard Hoffmann, Frederic Welsch, and Uwe Schweigkofler. "Stabilization of Acute High-Grade Acromioclavicular Joint Separation: A Prospective Assessment of the Clavicular Hook Plate Versus the Double Double-Button Suture Procedure." The American Journal of Sports Medicine 46, no. 11 (September 2018): 2725–34. https://doi.org/10.1177/0363546518788355.	49 (9.8)	II

Table 1. Continued

23	Mikek, Martin. "Long-Term Shoulder Function after Type I and II Acromioclavicular Joint Disruption." The American Journal of Sports Medicine 36, no. 11 (November 2008): 2147–50. https://doi.org/10.1177/0363546508319047.	49 (3.27)	IV
24	Andreani, Lorenzo, Enrico Bonicoli, Paolo Parchi, Nicola Piolanti, and Lisanti Michele. "Acromio-Clavicular Repair Using Two Different Techniques." European Journal of Orthopaedic Surgery & Traumatology: Orthopedie Traumatologie 24, no. 2 (February 2014): 237–42. https://doi.org/10.1007/s00590-013-1186-1.	46 (5.11)	III
25	Jensen, Gunnar, Jan Christoph Katthagen, Laura Alvarado, Helmut Lill, and Christine Voigt. "Arthroscopically Assisted Stabilization of Chronic AC-Joint Instabilities in GraftRopeTM Technique with an Additive Horizontal Tendon Augmentation." Archives of Orthopaedic and Trauma Surgery 133, no. 6 (June 2013): 841–51. https://doi.org/10.1007/s00402-013-1745-2.	45 (4.5)	III
26	Sage, F. P., and J. E. Salvatore. "Injuries of the Acromioclavicular Joint: A Study of Results in 96 Patients." Southern Medical Journal 56 (May 1963): 486–95. https://doi.org/10.1097/00007611-196305000-00009.	45 (0.75)	III
27	Yu, Y. S., M. Dardani, and R. A. Fischer. "MR Observations of Postraumatic Osteolysis of the Distal Clavicle after Traumatic Separation of the Acromioclavicular Joint." Journal of Computer Assisted Tomography 24, no. 1 (2000): 159–64. https://doi.org/10.1097/00004728-200001000-00028.	44 (1.91)	II
28	Gastaud, O., J. L. Raynier, F. Duparc, L. Baverel, K. Andrieu, N. Tarissi, and J. Barth. "Reliability of Radiographic Measurements for Acromioclavicular Joint Separations." Orthopaedics & Traumatology, Surgery & Research: OTSR 101, no. 8 Suppl (December 2015): S291-295. https://doi.org/10.1016/j.otsr.2015.09.010.	41 (5.13)	I
29	Black, G. B., J. A. McPherson, and M. H. Reed. "Traumatic Pseudodislocation of the Acromioclavicular Joint in Children. A Fifteen Year Review." The American Journal of Sports Medicine 19, no. 6 (1991): 644–46. https://doi.org/10.1177/036354659101900616.	37 (1.16)	III
30	Smith, M. J., and M. J. Stewart. "Acute Acromioclavicular Separations. A 20-Year Study." The American Journal of Sports Medicine 7, no. 1 (1979): 62–71. https://doi.org/10.1177/036354657900700113.	35 (0.80)	III
31	Patzer, T., C. Clauss, C. A. Kühne, E. Ziring, T. Efe, S. Ruchholtz, and D. Mann. "[Arthroscopically assisted reduction of acute acromioclavicular joint separations: comparison of clinical and radiological results of single versus double TightRopeTM technique]." Der Unfallchirurg 116, no. 5 (May 2013): 442–50. https://doi.org/10.1007/s00113-011-2135-2.	34 (3.4)	II
32	Kim, Sae Hoon, Young Ho Lee, Seung Han Shin, Ye Hyun Lee, and Goo Hyun Baek. "Outcome of Conjoined Tendon and Coracoacromial Ligament Transfer for the Treatment of Chronic Type V Acromioclavicular Joint Separation." Injury 43, no. 2 (February 2012): 213–18. https://doi.org/10.1016/j.injury.2011.08.003.	34 (3.09)	IV
33	Rosso, Claudio, Frank Martetschläger, Maristella F. Saccomanno, Andreas Voss, Lucca Lacheta, ESA DELPHI Consensus Panel, Knut Beitzel, and Giuseppe Milano. "High Degree of Consensus Achieved Regarding Diagnosis and Treatment of Acromioclavicular Joint Instability among ESA-ESSKA Members." Knee Surgery, Sports Traumatology, Arthroscopy: Official Journal of the ESSKA 29, no. 7 (July 2021): 2325–32. https://doi.org/10.1007/s00167-020-06286-w.	33 (16.5)	V
34	Falstie-Jensen, S., and P. Mikkelsen. "Pseudodislocation of the Acromioclavicular Joint." The Journal of Bone and Joint Surgery. British Volume 64, no. 3 (1982): 368–69. https://doi.org/10.1302/0301-620X.64B3.7096407.	33 (0.83)	IV
35	Schneider, M. M., M. Balke, P. Koenen, M. Fröhlich, A. Wafaisade, B. Bouillon, and M. Banerjee. "Inter- and Intraobserver Reliability of the Rockwood Classification in Acute Acromioclavicular Joint Dislocations." Knee Surgery, Sports Traumatology, Arthroscopy: Official Journal of the ESSKA 24, no. 7 (July 2016): 2192–96. https://doi.org/10.1007/s00167-014-3436-0.	28 (4)	IV
36	Heinz, W. M., and G. W. Misamore. "Mid-Shaft Fracture of the Clavicle with Grade III Acromioclavicular Separation." Journal of Shoulder and Elbow Surgery 4, no. 2 (1995): 141–42. https://doi.org/10.1016/s1058-2746(05)80069-2.	28 (0.74)	IV
37	Fleming, R. E., D. N. Tornberg, and H. Kiernan. "An Operative Repair of Acromioclavicular Separation." The Journal of Trauma 18, no. 10 (October 1978): 709–12. https://doi.org/10.1097/00005373-197810000-00005.	28 (0.62)	IV

Table 1. Continued

38	Spoliti, M., M. De Cupis, A. Giai Via, and F. Oliva. "All Arthroscopic Stabilization of Acute Acromioclavicular Joint Dislocation with Fiberwire and Endobutton System." Muscle Ligaments and Tendons Journal 04, no. 04 (January 2019): 398. https://doi.org/10.32098/mltj.04.2014.01.	27 (3.00)	III
39	Li, Haoqing, Chuanshun Wang, Jiandong Wang, Kai Wu, and Donghua Hang. "Restoration of Horizontal Stability in Complete Acromioclavicular Joint Separations: Surgical Technique and Preliminary Results." European Journal of Medical Research 18, no. 1 (November 13, 2013): 42. https://doi.org/10.1186/2047-783X-18-42.	24 (2.4)	IV
40	Neault, M. A., G. W. Nuber, and J. V. Marymont. "Infections after Surgical Repair of Acromioclavicular Separations with Nonabsorbable Tape or Suture." Journal of Shoulder and Elbow Surgery 5, no. 6 (1996): 477–78. https://doi.org/10.1016/s1058-2746(96)80021-8.	24 (0.89)	V
41	Müller, D., Y. Reinig, R. Hoffmann, M. Blank, F. Welsch, U. Schweigkofler, and T. Stein. "Return to Sport after Acute Acromioclavicular Stabilization: A Randomized Control of Double-Suture-Button System versus Clavicular Hook Plate Compared to Uninjured Shoulder Sport Athletes." Knee Surgery, Sports Traumatology, Arthroscopy: Official Journal of the ESSKA 26, no. 12 (December 2018): 3832–47. https://doi.org/10.1007/s00167-018-5044-x.	23 (4.6)	I
42	Porschke, Felix, Marc Schnetzke, Sara Aytac, Stefan Studier-Fischer, Paul Alfred Gruetzner, and Thorsten Guehring. "Sports Activity after Anatomic Acromioclavicular Joint Stabilisation with Flip-Button Technique." Knee Surgery, Sports Traumatology, Arthroscopy: Official Journal of the ESSKA 25, no. 7 (July 2017): 1995–2003. https://doi.org/10.1007/s00167-016-4287-7.	23 (3.83)	IV
43	Banffy, Michael B., Carola F. van Eck, and Neal S. ElAttrache. "Clinical Outcomes of a Single-Tunnel Technique for Coracoclavicular and Acromioclavicular Ligament Reconstruction." Journal of Shoulder and Elbow Surgery 27, no. 6S (June 2018): S70–75. https://doi.org/10.1016/j.jse.2017.11.032.	22 (4.4)	IV
44	Leidel, Bernd A., Volker Braunstein, Susann Pilotto, Wolf Mutschler, and Chlodwig Kirchhoff. "Mid-Term Outcome Comparing Temporary K-Wire Fixation versus PDS Augmentation of Rockwood Grade III Acromioclavicular Joint Separations." BMC Research Notes 2, no. 1 (2009): 84. https://doi.org/10.1186/1756-0500-2-84.	22 (1.57)	III
45	Saier, T., J. E. Plath, K. Beitzel, P. Minzlaff, J. M. Feucht, S. Reuter, F. Martetschläger, Andreas B. Imhoff, M. Aboalata, and S. Braun. "Return-to-Activity after Anatomical Reconstruction of Acute High-Grade Acromioclavicular Separation." BMC Musculoskeletal Disorders 17 (April 2, 2016): 145. https://doi.org/10.1186/s12891-016-0989-8.	20 (2.86)	III
46	Gille, Justus, Gerhard Heinrichs, Andreas Unger, Helge Riepenhof, Jan Herzog, Benjamin Kienast, and Ralf Oheim. "Arthroscopic-Assisted Hook Plate Fixation for Acromioclavicular Joint Dislocation." International Orthopaedics 37, no. 1 (January 2013): 77–82. https://doi.org/10.1007/s00264-012-1691-6.	18 (1.8)	IV
47	Jettoo, Prithee, Gavin De Kiewiet, and Simon England. "Base of Coracoid Process Fracture with Acromioclavicular Dislocation in a Child." Journal of Orthopaedic Surgery and Research 5, no. 1 (2010): 77. https://doi.org/10.1186/1749-799X-5-77.	18 (1.38)	V
48	Baldwin, Keith, Surena Namdari, Jaron R. Andersen, Brian Lee, John M. Itamura, and Russell G. Huffman. "Luggage Tag Technique of Anatomic Fixation of Displaced Acromioclavicular Joint Separations." Clinical Orthopaedics & Related Research 468, no. 1 (January 2010): 259–65. https://doi.org/10.1007/s11999-009-0877-8.	18 (1.38)	IV
49	Markel, Jochen, Tim Schwarting, Dominik Malcherczyk, Christian-Dominik Peterlein, Steffen Ruchholtz, and Bilal Farouk El-Zayat. "Concomitant Glenohumeral Pathologies in High-Grade Acromioclavicular Separation (Type III - V)." BMC Musculoskeletal Disorders 18, no. 1 (November 10, 2017): 439. https://doi.org/10.1186/s12891-017-1803-y.	17 (2.83)	III
50	Wang, Yeming, and Jianguo Zhang. "Acromioclavicular Joint Reconstruction by Coracoid Process Transfer Augmented with Hook Plate." Injury 45, no. 6 (June 2014): 949–54. https://doi.org/10.1016/j.injury.2013.12.013.	17 (1.89)	IV

The most common study type was a case series with 44% (22/50), followed by retrospective cohort study at 26% (13/50) prospective cohort study at 18% (9/50), and case report at 6% (3/50). Of the remaining categories: case-control, randomized control, and consensus study, only one paper of each kind fell into the top 50 most cited works [Table 2].

Table 2. Articles Classified by Study Type	
Study Type	**Frequency (number)**
Case Series	22 (44%)
Retrospective Cohort	13 (26%)
Prospective Cohort	9 (18%)
Case Report	3 (6%)
Case-Control	1 (2%)
Randomized Control	1 (2%)
Consensus Study	1(2%)

Seven total countries published all of the top most cited articles on this topic. Most publications came out of the United States at 64%. Next was Germany at 20%, then the United Kingdom, Luxembourg, and New Zealand at 4% each, and lastly the Netherlands at 2% [Figure 3]. 16 different journals contributed to the top 50 articles. The American Journal of Sports Medicine contributed the most, with a total of 16 articles. Out of the 33 articles that came out of the United States, 16 of these were from The American Journal of Sports Medicine. Clinical Orthopaedics and Related Research and Knee Surgery, Sports Traumatology were the second most cited journals with 6 articles each, all from the United States [Table 3]. The most common level of evidence was Level IV (22/50, 44%). 15 articles were level III, eight articles were level II, four articles were level V, and only two articles were level I [Figure 4].

When the list of the top 50 articles cited for acromioclavicular injuries were analyzed for citation density, Scheibel et al. was the leading article with 25 citations per year.[11] Rosso et al. and Milewski et al. followed with 16.5 and 15.64 per year respectively.[41,59] The range of citation density ranged from .62-25 with a mean of 5.07 per year. 15 articles were published in the twentieth century from 1963 to 1996 with an average citation density of 1.84. 35 articles were published in the twenty-first century from 2000-2021 with an average citation density of 6.46 [Table 1].

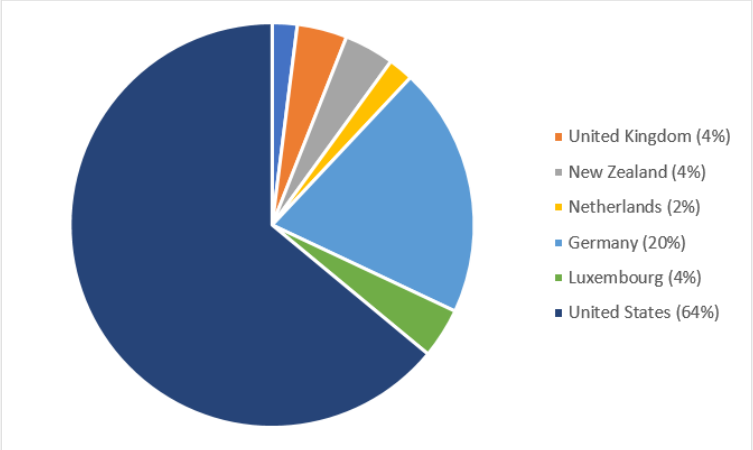

Figure 3. Articles per Country of Origin

Table 3. Journal of Origin	
Journal Title	**No. of Articles**
American Journal of Sports Medicine	16
Clinical Orthopaedics and Related Research	6
Knee Surgery, Sports Traumatology, Arthroscopy	6
Journal of Shoulder and Elbow Surgery	4
Journal of Trauma-Injury, Infection, and Critical Care	2
Injury	2

Table 3. Continued	
Journal of Orthopaedic Surgery and Research	1
European Journal of Orthopaedic Surgery and Traumatology	1
Archives of Orthopaedic and Trauma Surgery	1
Southern Medical Journal	1
Journal of Computer-Assisted Tomography	1
Orthopaedics and Traumatology: Surgery and Research	1
Unfallchirurg	1
European Journal of Medical Research	1
Muscles, Ligaments, and Tendons Journal	1
BMC Research Notes	1
BMC Musculoskeletal Disorders	1
International Orthopaedics	1
European Journal of Orthopaedic Surgery and Traumatology	2

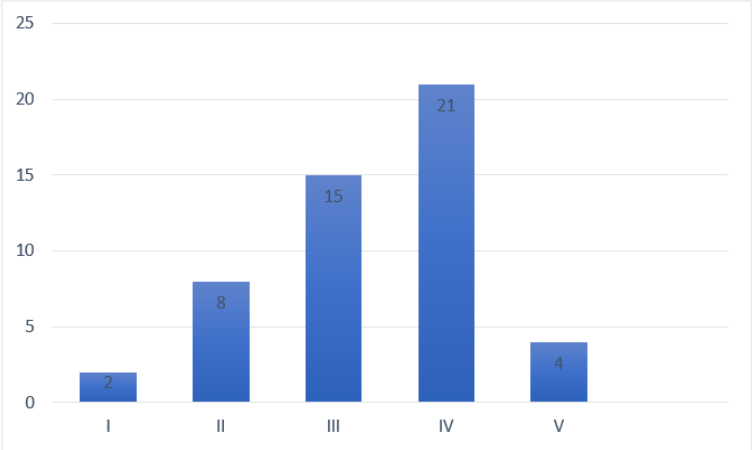

Figure 4: Articles Classified Per Level of Evidence

Discussion

30/50 of the 50 most cited articles researched various surgical techniques with the single and double tightrope, hook plate fixation, double-bundle, 2-flip button, and single-tunnel coracoclavicular ligament reconstruction being the most frequently discussed procedures. Additionally, two of the top three most densely cited articles, Scheibel et al and Milewski et al also discuss surgical techniques, double tight rope and anatomic reconstruction of the coracoclavicular ligaments with tendon graft, respectively.[11,59] The notable diversity in surgical methods underscores the evolutionary trajectory of AC joint surgery, highlighting both the advancements in surgical interventions and the absence of a consensus on the optimal approach. The shift towards arthroscopic procedures, favored for their minimally invasive nature and superior diagnostic capabilities for concomitant injuries, reflects a broader trend in orthopedic surgery towards techniques that promise quicker recovery and less morbidity.

The increased adoption of arthroscopic techniques is further evidenced by the discussion of concomitant injuries in four out of 50 articles, which are more readily identified through such procedures. Moreover, the debate over the efficacy of non-operative versus surgical treatments, addressed in another four articles, underscores the ongoing uncertainty regarding the optimal therapeutic strategy for AC joint separations. This is complemented by an assessment of the Rockman scale's validity and consensus of use among orthopedic surgeons in three of the articles, highlighting the challenges in standardizing evaluation and treatment methodologies within the field.

The concentration of publications in recent years, particularly during the 2012 to 2014 period, suggests a dynamic evolution in AC joint separation research. The dominance of case series, constituting 44% of the top 50 articles, highlights the reliance on clinical observations and low sample sizes. The scarcity of randomized controlled trials for surgical interventions in treating AC injury Type III

is attributed to existing evidence indicating that no surgical method fully alleviates symptoms with minimal side effects. A meta-analysis comparing surgical to non-surgical treatments found no significant differences in outcomes related to strength, pain, throwing ability, and the development of acromioclavicular joint osteoarthritis. Despite the prevalence of this injury, a definitive treatment standard has yet to be established, underscoring the need for a viable solution.[38]

While these studies provide valuable insights into practical applications, the predominance of level IV evidence raises questions about the overall strength of the evidence base guiding clinical practice. The prevalence of U.S.-based contributions may reflect the nation's prominence in sports medicine research, but it also prompts considerations about the global applicability of these findings. The lack of geographical distribution of research outputs signals the need for more diverse perspectives to enrich the understanding of AC joint separation on a global scale.

The study encountered several limitations. Firstly, despite searching across multiple platforms, access to all articles was not possible, leading to the exclusion of three articles due to unavailability. Due to this exclusion, data was lost that could have contributed. Second, one article was excluded due to language barriers; it was written in German, and reliable English translation services were not available. Germany is a significant contributor to current AC joint research, accounting for 20% of the articles in this review, however, the exclusion of even one out of 101 reviewed articles is noteworthy. Third, the focus on the top 50 cited articles introduces a selection bias, potentially excluding high-quality research with fewer citations. Similarly, newer articles, having had less time to accumulate citations, might have been overlooked, despite their relevance or quality.

Conclusion

This bibliometric analysis of the 50 most cited articles on acromioclavicular joint injury highlights a significant focus on diverse surgical techniques, reflecting the evolution of treatment approaches and the lack of consensus on optimal management. The dominance of case series and the prevalence of studies from the United States underscore the necessity for higher-level evidence and more geographically diverse research. The findings call for future efforts to be directed towards conducting randomized controlled trials and prospective studies, aiming to establish more definitive treatment guidelines for AC joint injuries.

Acknowledgement

N/A

Authors Contribution: Authors who conceived and designed the analysis: Grace Basralian, Paxton Sweeney, Eitan Kohan/ Authors who collected the data: Grace Basralian, Paxton Sweeney/ Authors who contributed data or analysis tools: Grace Basralian, Paxton Sweeney/ Authors who performed the analysis: Grace Basralian, Paxton Sweeney/ Authors who wrote the paper: Grace Basralian, Paxton Sweeney, Daniel Calem, Eitan Kohan

Declaration of Conflict of Interest: The authors do NOT have any relevant conflicts of interest related to this manuscript.

Declaration of Funding: The author(s) received NO financial support for the preparation, research, authorship, and publication of this manuscript.

Declaration of Ethical Approval for Study: This study did NOT require ethical approval as it was a bibliometric analysis with no interaction with patients or collection of identifiable personal data. All data used were publicly available, and no human participants were involved.

Declaration of Informed Consent: No names, initials, hospital identification numbers or photographs are included in the submitted manuscript that can be used to identify patients.

Grace L. Basralian BS [1]
Paxton Sweeney BA [1]
Daniel Calem MD [2]
Eitan Kohan MD [3]

1 Hackensack Meridian Health; Department of Orthopedic Surgery, NJ, USA
2 Rutgers Health New Jersey Medical School, Newark, NJ, USA
3 HMH Orthopedic Specialists of New Jersey, NJ, USA

References

1. Warth RJ, Martetschläger F, Gaskill TR, Millett PJ. Acromioclavicular joint separations. Curr Rev Musculoskelet Med. 2013; 6(1):71-78. doi:10.1007/s12178-012-9144-9.
2. Guzman AJ, Rayos Del Sol S, Dela Rueda T, et al. Open Acromioclavicular Repair With a Suture Cerclage Tensioning System: A Case Series. Cureus. 2023; 15(1):e34018. doi:10.7759/cureus.34018.
3. Gorbaty JD, Hsu JE, Gee AO. Classifications in Brief: Rockwood Classification of Acromioclavicular Joint Separations. Clin Orthop. 2017; 475(1):283-287. doi:10.1007/s11999-016-5079-6.
4. Berthold DP, Muench LN, Dyrna F, et al. Current concepts in acromioclavicular joint (AC) instability - a proposed treatment algorithm for acute and chronic AC-joint surgery. BMC Musculoskelet Disord. 2022; 23(1):1078. doi:10.1186/s12891-022-05935-0.
5. Mazzocca AD, Arciero RA, Bicos J. Evaluation and Treatment of Acromioclavicular Joint Injuries. Am J Sports Med. 2007; 35(2):316-329. doi:10.1177/0363546506298022.
6. de Groot C, Verstift DE, Heisen J, van Deurzen DFP, van den Bekerom MPJ. Management of Acromioclavicular Injuries - Current Concepts. Orthop Res Rev. 2023; 15:1-12. doi:10.2147/ORR.S340531.
7. Kavanagh RG, Kelly JC, Kelly PM, Moore DP. The 100 Classic

Papers of Pediatric Orthopaedic Surgery: A Bibliometric Analysis. J Bone Jt Surg. 2013; 95(18):e134. doi:10.2106/jbjs.l.01681.
8. Boddu SP, Moore ML, Rodgers BM, Brinkman JC, Verhey JT, Bingham JS. A Bibliometric Analysis of the Top 100 Most Influential Studies on Robotic Arthroplasty. Arthroplasty Today. 2023; 22:101153. doi:10.1016/j.artd.2023.101153.
9. Fanfan D, Larios F, Gonzalez MR, et al. A Bibliometric Analysis of the 500 Most Cited Papers in Orthopaedic Oncology. J Am Acad Orthop Surg Glob Res Rev. 2024; 8(1):e23.00223. doi:10.5435/JAAOSGlobal-D-23-00223.
10. Marx RG, Wilson SM, Swiontkowski MF. Updating the Assignment of Levels of Evidence. J Bone Jt Surg. 2015; 97(1):1-2. doi:10.2106/JBJS.N.01112.
11. Scheibel M, Dröschel S, Gerhardt C, Kraus N. Arthroscopically assisted stabilization of acute high-grade acromioclavicular joint separations. Am J Sports Med. 2011; 39(7):1507-1516. doi:10.1177/0363546511399379.
12. Kaplan LD, Flanigan DC, Norwig J, Jost P, Bradley J. Prevalence and variance of shoulder injuries in elite collegiate football players. Am J Sports Med. 2005; 33(8):1142-1146. doi:10.1177/0363546505274718.
13. Salzmann GM, Walz L, Buchmann S, Glabgly P, Venjakob A, Imhoff AB. Arthroscopically assisted 2-bundle anatomical reduction of acute acromioclavicular joint separations. Am J Sports Med. 2010; 38(6):1179-1187. doi:10.1177/0363546509355645.
14. Black GB, McPherson JA, Reed MH. Traumatic pseudodislocation of the acromioclavicular joint in children. A fifteen year review. Am J Sports Med. 1991; 19(6):644-646. doi:10.1177/036354659101900616.
15. Sim E, Schwarz N, Höcker K, Berzlanovich A. Repair of complete acromioclavicular separations using the acromioclavicular-hook plate. Clin Orthop. 1995 ;(314):134-142.
16. Tischer T, Salzmann GM, El-Azab H, Vogt S, Imhoff AB. Incidence of associated injuries with acute acromioclavicular joint dislocations types III through V. Am J Sports Med. 2009;37(1):136-139. doi:10.1177/0363546508322891.
17. Galpin RD, Hawkins RJ, Grainger RW. A comparative analysis of operative versus nonoperative treatment of grade III acromioclavicular separations. Clin Orthop. 1985 ;(193):150-155.
18. Schlegel TF, Burks RT, Marcus RL, Dunn HK. A prospective evaluation of untreated acute grade III acromioclavicular separations. Am J Sports Med. 2001; 29(6):699-703. doi:10.1177/03635465010290060401.
19. Jensen G, Katthagen JC, Alvarado LE, Lill H, Voigt C. Has the arthroscopically assisted reduction of acute AC joint separations with the double tight-rope technique advantages over the clavicular hook plate fixation? Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 2014; 22(2):422-430. doi:10.1007/s00167-012-2270-5.
20. Morrison DS, Lemos MJ. Acromioclavicular separation. Reconstruction using synthetic loop augmentation. Am J Sports Med. 1995; 23(1):105-110. doi:10.1177/036354659502300118.
21. Venjakob AJ, Salzmann GM, Gabel F, et al. Arthroscopically assisted 2-bundle anatomic reduction of acute acromioclavicular joint separations: 58-month findings. Am J Sports Med. 2013; 41(3):615-621. doi:10.1177/0363546512473438.
22. Pauly S, Kraus N, Greiner S, Scheibel M. Prevalence and pattern of glenohumeral injuries among acute high-grade acromioclavicular joint instabilities. J Shoulder Elbow Surg. 2013; 22(6):760-766. doi:10.1016/j.jse.2012.08.016.
23. Pauly S, Gerhardt C, Haas NP, Scheibel M. Prevalence of concomitant intraarticular lesions in patients treated operatively for high-grade acromioclavicular joint separations. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 2009; 17(5):513-517. doi:10.1007/s00167-008-0666-z.
24. Yoo JC, Ahn JH, Yoon JR, Yang JH. Clinical results of single-tunnel coracoclavicular ligament reconstruction using autogenous semitendinosus tendon. Am J Sports Med. 2010; 38(5):950-957. doi:10.1177/0363546509356976.
25. Hessmann M, Gotzen L, Gehling H. Acromioclavicular reconstruction augmented with polydioxanonsulphate bands. Surgical technique and results. Am J Sports Med. 1995; 23(5):552-556. doi:10.1177/036354659502300506.
26. MacDonald PB, Alexander MJ, Frejuk J, Johnson GE. Comprehensive functional analysis of shoulders following complete acromioclavicular separation. Am J Sports Med. 1988; 16(5):475-480. doi:10.1177/036354658801600508.
27. Lancaster S, Horowitz M, Alonso J. Complete acromioclavicular separations. A comparison of operative methods. Clin Orthop. 1987 ;(216):80-88.
28. Leidel BA, Braunstein V, Kirchhoff C, Pilotto S, Mutschler W, Biberthaler P. Consistency of long-term outcome of acute Rockwood grade III acromioclavicular joint separations after K-wire transfixation. J Trauma. 2009; 66(6):1666-1671. doi:10.1097/TA.0b013e31818c1455.
29. Tomlinson DP, Altchek DW, Davila J, Cordasco FA. A modified technique of arthroscopically assisted AC joint reconstruction and preliminary results. Clin Orthop. 2008; 466(3):639-645. doi:10.1007/s11999-007-0085-3.
30. Bargren JH, Erlanger S, Dick HM. Biomechanics and comparison of two operative methods of treatment of complete acromioclavicular separation. Clin Orthop. 1978 ;(130):267-272.
31. Park JP, Arnold JA, Coker TP, Harris WD, Becker DA. Treatment of acromioclavicular separations. A retrospective study. Am J Sports Med. 1980; 8(4):251-256. doi:10.1177/036354658000800407.
32. Stein T, Müller D, Blank M, et al. Stabilization of Acute High-Grade Acromioclavicular Joint Separation: A Prospective Assessment of the Clavicular Hook Plate versus the Double Double-Button Suture Procedure. Am J Sports Med. 2018; 46(11):2725-2734. doi:10.1177/0363546518788355.
33. Mikek M. Long-term shoulder function after type I and II acromioclavicular joint disruption. Am J Sports Med. 2008; 36(11):2147-2150. doi:10.1177/0363546508319047.
34. Andreani L, Bonicoli E, Parchi P, Piolanti N, Michele L. Acromio-clavicular repair using two different techniques. Eur J Orthop Surg Traumatol Orthop Traumatol. 2014; 24(2):237-242. doi:10.1007/s00590-013-1186-1.
35. Sage FP, Salvatore JE. Injuries of the acromioclavicular joint: a study of results in 96 patients. South Med J. 1963; 56:486-

495. doi:10.1097/00007611-196305000-00009.
36. Yu YS, Dardani M, Fischer RA. MR observations of posttraumatic osteolysis of the distal clavicle after traumatic separation of the acromioclavicular joint. J Comput Assist Tomogr. 2000; 24(1):159-164. doi:10.1097/00004728-200001000-00028.
37. Gastaud O, Raynier JL, Duparc F, et al. Reliability of radiographic measurements for acromioclavicular joint separations. Orthop Traumatol Surg Res OTSR. 2015; 101(8 Suppl):S291-295. doi:10.1016/j.otsr.2015.09.010.
38. Smith MJ, Stewart MJ. Acute acromioclavicular separations. A 20-year study. Am J Sports Med. 1979; 7(1):62-71. doi:10.1177/036354657900700113.
39. Patzer T, Clauss C, Kühne CA, et al. [Arthroscopically assisted reduction of acute acromioclavicular joint separations: comparison of clinical and radiological results of single versus double TightRopeTM technique]. Unfallchirurg. 2013; 116(5):442-450. doi:10.1007/s00113-011-2135-2.
40. Kim SH, Lee YH, Shin SH, Lee YH, Baek GH. Outcome of conjoined tendon and coracoacromial ligament transfer for the treatment of chronic type V acromioclavicular joint separation. Injury. 2012; 43(2):213-218. doi:10.1016/j.injury.2011.08.003.
41. Rosso C, Martetschläger F, Saccomanno MF, et al. High degree of consensus achieved regarding diagnosis and treatment of acromioclavicular joint instability among ESA-ESSKA members. Knee Surg Sports Traumatol Arthrosc. 2021; 29(7):2325-2332. doi:10.1007/s00167-020-06286-w.
42. Falstie-Jensen S, Mikkelsen P. Pseudodislocation of the acromioclavicular joint. J Bone Joint Surg Br. 1982; 64(3):368-369. doi:10.1302/0301-620X.64B3.7096407.
43. Schneider MM, Balke M, Koenen P, et al. Inter- and intraobserver reliability of the Rockwood classification in acute acromioclavicular joint dislocations. Knee Surg Sports Traumatol Arthrosc. 2016; 24(7):2192-2196. doi:10.1007/s00167-014-3436-0.
44. Heinz WM, Misamore GW. Mid-shaft fracture of the clavicle with grade III acromioclavicular separation. J Shoulder Elbow Surg. 1995; 4(2):141-142. doi:10.1016/s1058-2746(05)80069-2.
45. Fleming RE, Tornberg DN, Kiernan H. An operative repair of acromioclavicular separation. J Trauma. 1978; 18(10):709-712. doi:10.1097/00005373-197810000-00005.
46. Spoliti M, De Cupis M, Giai Via A, Oliva F. All arthroscopic stabilization of acute acromioclavicular joint dislocation with fiberwire and endobutton system. Muscle Ligaments Tendons J. 2019; 04(04):398. doi:10.32098/mltj.04.2014.01.
47. Li H, Wang C, Wang J, Wu K, Hang D. Restoration of horizontal stability in complete acromioclavicular joint separations: surgical technique and preliminary results. Eur J Med Res. 2013; 18(1):42. doi:10.1186/2047-783X-18-42.
48. Neault MA, Nuber GW, Marymont JV. Infections after surgical repair of acromioclavicular separations with nonabsorbable tape or suture. J Shoulder Elbow Surg. 1996; 5(6):477-478. doi:10.1016/s1058-2746(96)80021-8.
49. Müller D, Reinig Y, Hoffmann R, et al. Return to sport after acute acromioclavicular stabilization: a randomized control of double-suture-button system versus clavicular hook plate compared to uninjured shoulder sport athletes. Knee Surg Sports Traumatol Arthrosc. 2018; 26(12):3832-3847. doi:10.1007/s00167-018-5044-x.
50. Porschke F, Schnetzke M, Aytac S, Studier-Fischer S, Gruetzner PA, Guehring T. Sport's activity after anatomic acromioclavicular joint stabilisation with flip-button technique. Knee Surg Sports Traumatol Arthrosc. 2017; 25(7):1995-2003. doi:10.1007/s00167-016-4287-7
51. Banffy MB, van Eck CF, ElAttrache NS. Clinical outcomes of a single-tunnel technique for coracoclavicular and acromioclavicular ligament reconstruction. J Shoulder Elbow Surg. 2018; 27(6S):S70-S75. doi:10.1016/j.jse.2017.11.032.
52. Leidel BA, Braunstein V, Pilotto S, Mutschler W, Kirchhoff C. Mid-Term outcome comparing temporary K-Wire fixation versus PDS augmentation of Rockwood grade III acromioclavicular joint separations. BMC Res Notes. 2009; 2(1):84. doi:10.1186/1756-0500-2-84.
53. Saier T, Plath JE, Beitzel K, et al. Return-to-activity after anatomical reconstruction of acute high-grade acromioclavicular separation. BMC Musculoskelet Disord. 2016; 17:145. doi:10.1186/s12891-016-0989-8.
54. Gille J, Heinrichs G, Unger A, et al. Arthroscopic-assisted hook plate fixation for acromioclavicular joint dislocation. Int Orthop. 2013; 37(1):77-82. doi:10.1007/s00264-012-1691-6.
55. Jettoo P, De Kiewiet G, England S. Base of coracoid process fracture with acromioclavicular dislocation in a child. J Orthop Surg. 2010; 5(1):77. doi:10.1186/1749-799X-5-77.
56. Baldwin K, Namdari S, Andersen JR, Lee B, Itamura JM, Huffman RG. Luggage Tag Technique of Anatomic Fixation of Displaced Acromioclavicular Joint Separations. Clin Orthop. 2010; 468(1):259-265. doi:10.1007/s11999-009-0877-8.
57. Markel J, Schwarting T, Malcherczyk D, Peterlein CD, Ruchholtz S, El-Zayat BF. Concomitant glenohumeral pathologies in high-grade acromioclavicular separation (type III - V). BMC Musculoskelet Disord. 2017; 18(1):439. doi:10.1186/s12891-017-1803-y.
58. Wang Y, Zhang J. Acromioclavicular joint reconstruction by coracoid process transfer augmented with hook plate. Injury. 2014; 45(6):949-954. doi:10.1016/j.injury.2013.12.013.
59. Milewski MD, Tompkins M, Giugale JM, Carson EW, Miller MD, Diduch DR. Complications related to anatomic reconstruction of the coracoclavicular ligaments. Am J Sports Med. 2012; 40(7):1628-1634. doi:10.1177/0363546512445273.