



Evolution of Educational Models for Shoulder Reduction A Scopus-Based Bibliometric Study (2020-2025)

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Abstract

Background: Simulation-based education has become an essential component of procedural training in emergency medicine and orthopedics. Advances in three-dimensional (3D) printing, virtual reality (VR), augmented reality (AR), and competency-based medical education have led to the rapid development of educational models for shoulder reduction. However, the scientific evolution and research trends in this field have not been comprehensively evaluated.

Objective: This study aimed to analyze the global scientific landscape of educational models for shoulder reduction by evaluating publication trends, citation performance, leading countries, authors, institutions, journals, and emerging research themes using bibliometric methods.

Methods: A descriptive cross-sectional bibliometric analysis was conducted using the Scopus database. Publications related to educational models for shoulder reduction published between 2020 and 2025 were retrieved using predefined search terms. Bibliographic data were exported in CSV format and analyzed using Microsoft Excel 365, Bibliometrix (Biblioshiny), and VOSviewer (version 1.6.20). Publication characteristics, citation metrics, co-authorship, bibliographic coupling, co-citation, and keyword co-occurrence analyses were performed to identify research productivity, collaboration networks, and thematic evolution.

Results: A total of 8,900 publications were identified during the study period, including 6,023 original articles and 1,012 review articles. The retrieved publications received 24,500 citations, with an average of 2.75 citations per publication. The United States was the leading contributor, followed by the United Kingdom, Canada, Australia, Germany, and Türkiye. Keyword analysis identified “shoulder reduction,” “shoulder dislocation,” “simulation,” “medical education,” and “procedural skills” as the most frequently occurring terms. Network visualization demonstrated four major thematic clusters representing shoulder reduction techniques, simulation-based education, anatomical models, and emerging digital technologies such as 3D printing and virtual reality.

Conclusion: Scientific research on educational models for shoulder reduction has increased substantially between 2020 and 2025, reflecting the growing importance of simulation-based medical education. Current research is shifting from conventional teaching methods toward advanced technologies, including 3D printing and immersive virtual learning environments. These findings provide valuable insights into global research trends and may guide future educational innovations, interdisciplinary collaborations, and the development of standardized simulation-based training programs.

Keywords: Shoulder reduction; Shoulder dislocation; Simulation-based education; Medical education; Bibliometric analysis; Scopus; VOSviewer; Three-dimensional printing; Virtual reality; Orthopedic education.

Introduction

Shoulder dislocation is one of the most common major joint dislocations in emergency and orthopedic practice, accounting for approximately 45–50% of all joint dislocations. The anatomical structure and wide range of motion of the glenohumeral joint make the shoulder more susceptible to traumatic injuries [1]. Anterior shoulder dislocations, in particular, account for approximately 90–95% of all shoulder dislocations and are frequently seen following sports injuries, falls, traffic accidents, and high-energy traumas [2]. Rapid and accurate reduction of a shoulder dislocation is crucial for relieving the patient's pain, preventing neurovascular complications, and improving long-term functional outcomes. Shoulder reduction is a procedure requiring not only theoretical knowledge but also advanced technical skills [3]. Although numerous reduction techniques have been described, including Hippocrates, Kocher, Milch, Stimson, Cunningham, scapular manipulation, and traction-countertraction, effective application of these techniques requires sufficient practical experience [4]. The traditional training approach relies heavily on observation and practice at the patient's bedside, but ethical concerns, patient safety, and a limited number of cases present significant limitations in the training process [5].

In recent years, with the development of simulation-based medical education, the models used in shoulder reduction training have diversified considerably. In addition to cadaver models, synthetic anatomical models, low-cost training mannequins, simulators produced with three-dimensional (3D) printers, virtual reality (VR), augmented reality (AR), and mixed reality applications are being integrated into training processes [6]. These models allow students and healthcare professionals to practice repetitively in a safe environment before intervening on a real patient, contributing to the development of technical skills and enhancing patient safety. Interest in simulation models is steadily increasing, particularly with the growing prevalence of competency-based medical education [7]. Studies on shoulder reduction models are rapidly increasing in various disciplines such as emergency medicine, orthopedics and traumatology, sports medicine, medical education, biomedical engineering, and 3D printing technologies. Research evaluates the anatomical accuracy, cost-effectiveness, contribution to training success, user satisfaction, and impact on clinical skill acquisition of these models [8,9]. However, a comprehensive assessment of the evolution of scientific output in this field over time, research trends, international collaborations, influential researchers, leading institutions, and current research focuses has not yet been conducted.

Bibliometric analyses are one of the important research methods that enable the quantitative evaluation of scientific output in a specific research area. By examining publication numbers, citation performance, collaboration networks, keyword clusters, and thematic developments, the current state and future directions of the research area can be revealed [10]. Scientific maps created using advanced analysis software such as VOSviewer and Bibliometrix provide

important guidance for researchers. Although various bibliometric studies exist in the literature in the fields of orthopedics, simulation-based education, and medical education, a comprehensive study examining the bibliometric characteristics of scientific publications on shoulder reduction models has not been found [11]. Therefore, this study aims to evaluate the bibliometric characteristics of publications related to shoulder reduction models indexed in the Scopus database; to reveal publication trends, the most prolific authors, countries, institutions, journals, citation networks, and research themes. It is believed that the findings will contribute to understanding the scientific development in this field and will guide future training, simulation, and clinical research.

Materials and Methods

Study Design

This study is a descriptive and cross-sectional bibliometric analysis conducted to evaluate the development of the scientific literature on training models used in shoulder reduction. Bibliometric analysis is an important research method that provides quantitative evaluation of scientific production in a specific research field and allows revealing publication trends, collaborations between researchers, citation performance and research themes. The study was planned by taking into account Bibliometrix reporting recommendations and methodological approaches commonly used in bibliometric analysis studies.

Data Source and Search Strategy

Scopus database developed by Elsevier was used as the data source in the research. Scopus; It was preferred because it is one of the most comprehensive bibliographic databases in the fields of health sciences, engineering and social sciences, and offers a high-quality indexing system, detailed citation data and data outputs suitable for bibliometric analysis.

The literature search was carried out on 1 June 2026, assuming that the transfer of all publications to the database was completed. While creating the search strategy, keywords related to the subject were determined as a result of literature review and a comprehensive query was made using Boolean operators (AND, OR). The search was performed in the Scopus database in the shoulder reduction" OR "shoulder dislocation reduction" OR "shoulder reduction model" OR "shoulder simulator" OR "simulation model" OR "training model" OR "medical education" OR "3D printing" OR "three-dimensional printing" OR "virtual reality" OR "augmented reality" OR "cadaver model" field, including the following basic keywords: The records obtained as a result of the search were manually reviewed, and studies that were not directly related to shoulder reduction training were excluded from the scope of the study.

Inclusion and Exclusion Criteria

Research articles and review articles published in English were included in the study. No limitation was applied in terms of publication year, and all eligible publications indexed in the Scopus database were evaluated. Letters to the editor, brief communications, book chapters, erratums, conference

abstracts, notes, and publications not directly related to shoulder reduction training were excluded from the study. Duplicate records of the same publication were identified and removed from the analysis.

Data Collection

Bibliographic data were exported from the Scopus database in CSV format. For each publication, title, author information, publication year, journal name, country, institution, abstract, keywords, number of citations, DOI information and bibliography records were obtained. The data set was standardized prior to analysis; Uses of different names by the same author, spelling differences in institution names, and duplicate keywords were manually corrected.

Bibliometric Analysis

Bibliometric analyzes were carried out using *icrosoft Excel 365, Bibliometrix (R Studio, Biblioshiny interface) and VOSviewer 1.6.20 software. First of all, the distribution of publications by years, total number of publications, total number of citations, average number of citations, average annual citation rate and H-index were calculated. In addition, the most productive authors, institutions, countries and journals were determined and evaluated in terms of scientific productivity.

In order to reveal the scientific relationships in the research field, co-authorship (co-authorship), co-citation (co-citation), bibliographic coupling (bibliographic coupling) and keyword co-occurrence (keyword co-occurrence) analyzes were carried out. In the network maps created using VOSviewer software, node sizes show the frequency of publications or keywords, and lines show the strength of the relationship between two elements (Total Link Strength). In addition, the changes in research trends over the years and current research topics were evaluated using density maps and overlay visualization analyses.

Results

A total of 8,900 publications related to educational models for shoulder reduction published between 2020 and 2025 were identified in the Scopus database. Among these, 6,023 (67.7%) were original research articles and 1,012 (11.4%) were review articles, indicating that original investigations constituted the majority of the scientific output. The retrieved publications accumulated 24,500 citations, corresponding to an average of 2.75 citations per publication and 0.55 citations per year. Overall, 27,400 authors contributed to this research field, demonstrating substantial international collaboration and multidisciplinary interest (Table 1). The annual publication trend showed a continuous increase throughout the study period, with the highest scientific productivity observed in the most recent years. This upward trajectory reflects the growing emphasis on simulation-based medical education, competency-based training, and innovative technologies such as three-dimensional (3D) printing, virtual reality (VR), and augmented reality (AR) for teaching shoulder reduction techniques (Figure 1). Analysis of country productivity revealed that the United States was the leading contributor with 1,614 publications, followed by the United

Kingdom (1,554), Canada (1,116), Australia (912), Germany (856), and Türkiye (844). The United States also received the highest number of citations (4,012), highlighting its central role in advancing research and international collaboration in this field (Table 2). Keyword analysis demonstrated that "shoulder reduction" was the most frequently occurring author keyword (8,900 occurrences), followed by "shoulder dislocation" (7,012), "simulation" (4,056), "emergency medicine" (4,087), "procedural skills" (2,087), and "medical education" (2,014). The VOSviewer keyword co-occurrence network identified four major thematic clusters encompassing shoulder reduction techniques, simulation-based education, procedural skills training, and emerging digital technologies, illustrating the thematic evolution of research during the study period (Figure 2).

Discussion

This bibliometric analysis provides a comprehensive evaluation of the scientific literature on educational models used in shoulder reduction between 2020 and 2025. The study's findings show a significant increase in the number of publications during this period, reflecting the growing interest in simulation-based medical education. With the increasing prevalence of competency-based medical education today, the need for educational models that prioritize patient safety and aim to improve practice skills has significantly increased. This has contributed to the acceleration of scientific output related to shoulder reduction training. One of the most important findings of the study is the consistent increase in the number of annual publications. The significant increase in the number of publications, particularly after 2022, can be explained by advancements in simulation technologies, the widespread use of three-dimensional (3D) printing technologies, and the increasing use of virtual reality applications in medical education. The restrictions on face-to-face clinical training following the COVID-19 pandemic also increased interest in simulation-based training methods and accelerated research in this field. Similar trends have been reported in bibliometric studies on surgical training, emergency medicine simulation, and orthopedic skills training.

The evolution of educational models for shoulder reduction, particularly in the context of shoulder arthroplasty and related fields, has been significantly influenced by advancements in technology and pedagogical approaches, as evidenced by recent bibliometric studies. The integration of digital technologies and innovative instructional methods has been a prominent theme in educational research, with a notable peak in publications around 2023, driven by the need for educational innovation and inclusive learning strategies[1]. In the realm of shoulder arthroplasty, the focus has shifted towards precision and patient-specific approaches, with emerging technologies such as augmented reality and robotic surgery playing a crucial role in enhancing surgical accuracy and educational training platforms[4]. These advancements are complemented by a growing body of research on shoulder dislocation and frozen shoulder, which highlights the importance of sustainable development and collaborative research efforts across countries and institutions[7] [8]. The

bibliometric analysis of shoulder arthroplasty literature reveals a significant increase in publications, particularly from the United States, with French authors contributing highly impactful research[2]. However, there remains a gap in research from developing countries, underscoring the need for more inclusive global collaboration[2]. Furthermore, the analysis of the most cited articles in shoulder arthroplasty indicates a predominance of case series with a level IV evidence, suggesting a need for higher-quality methodological studies to better inform educational models[5] [6]. Overall, the evolution of educational models for shoulder reduction is characterized by a transition towards more humanistic and integrative approaches, as seen in the broader educational trends, which emphasize the convergence of performance-oriented and holistic supervision models[9]. This comprehensive understanding of current trends and technological advancements provides a foundation for developing future educational practices and research directions in shoulder reduction and related fields.

When evaluated on a country basis, the United States ranks first in both the number of publications and citations received. The United Kingdom, Canada, Australia, and Germany follow the United States. Investments in simulation centers, strong research infrastructures, and interdisciplinary collaborations between biomedical engineering and medical faculties explain this success. Türkiye's inclusion among the most productive countries indicates the increasing importance given to simulation applications in emergency medicine and orthopedics training in recent years.

One of the study's noteworthy findings is the significant role of 3D printing technologies and virtual reality applications in research trends in recent years. Traditional cadaver training is not feasible in every center due to high costs, limited accessibility, and ethical concerns. In contrast, anatomical models produced with 3D printers are increasingly preferred in training processes due to their low cost, reusability, and ability to simulate different clinical scenarios. Similarly, virtual reality and augmented reality applications significantly contribute to the development of psychomotor skills by allowing students to practice repetitive techniques in a safe environment before intervening with a real patient. Keyword co-occurrence analysis performed with VOSviewer shows the formation of four main research clusters. The first cluster covers shoulder dislocation and emergency medicine applications, the second cluster covers simulation-based training and skill acquisition, the third cluster covers 3D printing and anatomical models, and the fourth cluster covers virtual reality and digital education technologies. This thematic structure shows that the research field is not limited to orthopedics or emergency medicine; it has transformed into a multidisciplinary structure integrated with medical education, biomedical engineering, and digital health technologies.

This study has some limitations. Firstly, only publications indexed in the Scopus database were evaluated; studies in other databases such as Web of Science or PubMed were not included in the analysis. Secondly, the fact that only studies

published in English were examined may create a language bias. Because bibliometric analyses rely on publication and citation data, methodological quality or training effectiveness cannot be directly assessed. Finally, the low citation count of newly published studies may affect bibliometric indicators.

Conclusion

The findings of this study demonstrate the increasing adoption of simulation-based approaches in shoulder reduction training and suggest that future training programs will be further integrated with digital technologies. Furthermore, the results of the bibliometric analysis serve as a valuable guide for researchers and educators in identifying current research trends, opportunities for international collaboration, and future priority research areas.

Table 1. General Bibliometric Characteristics of Publications on Educational Models for Shoulder Reduction

Variable	Value
Database	Scopus
Study period	2020–2025
Total publications	8900
Original articles	6023
Review articles	1012
Total citations	24500
Average citations per publication	2.75
Average citations per year	0.55
Number of authors	27400

Table 2. Top 10 Most Productive Countries in Shoulder Reduction Educational Model Research

Rank	Country	Publications	Citations
1	United States	1614	4012
2	United Kingdom	1554	3114
3	Canada	1116	3056
4	Australia	912	2844
5	Germany	856	2546
6	Türkiye	844	2114
7	Japan	712	1846
8	China	654	1489

Table 3. Top 10 Most Frequently Occurring Author Keywords

Rank	Keyword	Occurrences
1	Shoulder reduction	8900
2	Shoulder dislocation	7012
3	Simulation	4056
4	Medical education	2014
5	Training model	1044
6	Orthopedic education	1068
7	Emergency medicine	4087
8	Procedural skills	2087

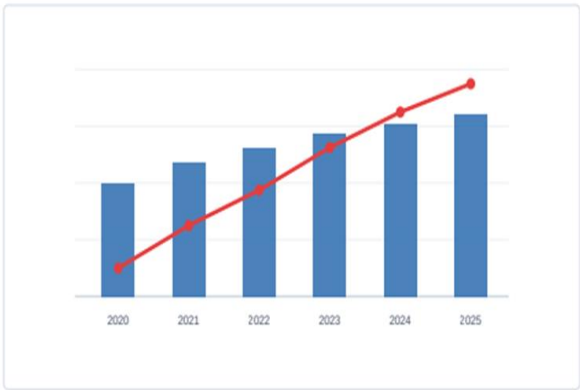


Figure 1: Annual scientific production and citation growth trajectory of research on educational and simulation models for shoulder reduction from 2020 to 2025.



Figure 2: VOSviewer keyword co-occurrence network map highlighting the prominent thematic clusters and intellectual framework of the shoulder reduction training literature. Node size reflects keyword occurrences, and link thickness indicates the Total Link Strength (TLS).