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Review Article

The utility of platelet-rich plasma in modern orthopedic practices: a review of the literature

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Conflicts of Interest Statement for John Barnett

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f As an orthopedic surgeon with a subspecialty in sports medicine and shoulder surgery, Dr. Cvetanovich performs the most advanced surgical techniques of the shoulder and elbow. He uses nonoperative treatments whenever possible and uses surgery when it is the best option for the patient and their shoulder problem. He specializes in arthroscopic surgery including rotator cuff repair and labral repair as well as anatomic and reverse shoulder replacement and revision surgery.

In order to provide individualized care to each patient, he begins by listening to their unique problems and goals. He aims to help patients understand their orthopedic conditions and work with them to choose the best treatment to help them return to their activities. He is passionate about helping people of all ages and backgrounds regain their quality of life and return to the activities they love.

Working at The Ohio State University Wexner Medical Center allows him to provide cutting-edge clinical care to patients. He takes pride in collaborating with a team of sports medicine experts and participating in clinical research that improves treatments for our patients. He also enjoys serving as a team physician for high school, collegiate and professional athletes, including the Columbus Clippers (AAA affiliate of Cleveland Indians).

When he's not at work, he enjoys spending time with my family, as well as running, skiing, baseball, and hiking.

Conflicts of Interest Statement for Dr. Cvetanovich

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h Dr. Rauck is an orthopedic surgeon with a subspecialty in sports medicine and shoulder surgery. He takes the time to understand each patient's concerns, goals and expectations while providing a clear explanation of the diagnosis and treatment options, which can range from non-operative solutions to minimally invasive arthroscopic or open surgeries for patients of all ages. He is passionate about helping his patients alleviate their pain and improving their function to get them back to doing the things that they enjoy.

He developed a focus on patient care, research and education while training at the world-renowned Hospital for Special Surgery in New York City. However, as someone who was born and raised in Columbus, The Ohio State University Wexner Medical Center has always been a special place to him. The team-based approach and willingness to address any problem, no matter how complex, set Ohio State apart for providing the best care possible to patients and made it the ideal place to continue his career. He's served as a team physician and taken care of athletes at all levels of competition, including providing care as an assistant team physician with the New York Giants. He also enjoys taking care of the athletes at Ohio State.

His research interests include enhancing our understanding of shoulder instability and available treatment options as well as patient expectations and clinical outcomes for shoulder replacements and rotator cuff repairs.
When not at work, he enjoys spending time with his family as well as playing tennis and hiking.

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Introduction

Citation analysis is a useful tool to understand the contributions publications make within their fields. As the use of platelet-rich plasma (PRP) by orthopedic shoulder and elbow surgeons increases, it is vital to highlight influential literature that may inform readers of innovations, new applications, and current trends within PRP research. The purpose of this study was to identify and analyze the 50 most-cited publications related to the use of PRP in shoulder and elbow orthopedics.

Methods

The Clarivate Analytics Web of Science Database was searched using various Boolean searches. Author name, journal, study type, publication year, number of citations, level of evidence, and geographical origin were recorded for each publication.

Results

Included publications accumulated 6318 total citations with the most-cited article achieving 561 citations. Most studies were randomized controlled trials of Level I evidence. Authors from the United States (10) produced the most publications, and nearly half (22) of the articles were published in the American Journal of Sports Medicine.

Discussion

Randomized controlled trials composed much of this analysis. As PRP use within upper extremity orthopedics is refined, studies demonstrating evidence in favor of PRP may replace the publications reviewed in this analysis.

INTRODUCTION

Platelet-rich plasma (PRP), a concentrated autologous solution derived from a patient's own blood, has gained recognition as a promising approach in regenerative medicine, specifically for addressing shoulder and elbow conditions. PRP was originally introduced in 1972 as a coagulant to maintain blood homeostasis during surgery (Mościcka and Przylipiak 2021). Since then, PRP has been found to release growth factors that stimulate angiogenesis, cell recruitment, and proliferation. By delivering a concentrated dose of these vital bioactive substances directly to the affected area, PRP aims to enhance the body's natural healing mechanisms, first demonstrated in humans in 2006 (Mishra and Pavelko 2006).

The use of PRP has dramatically increased in the past two decades, and numerous studies have investigated the efficacy of PRP in the management of shoulder and elbow pathologies (Castricini et al. 2011; Liu et al. 2021; Antuña et al. 2013; Hsu et al. 2013). These investigations have explored PRP as a standalone treatment or as an adjunct to surgical interventions with applications in tendinopathies, osteoarthritis, and chronic soft-tissue injuries with the goal of optimizing the healing environment to improve patient outcomes (Lopez-Vidriero et al. 2010; Hall et al. 2009). Given the increasing interest and utilization of PRP in shoulder and elbow treatments, it is essential to identify and examine the most influential publications in the field. Citation analysis serves as a valuable tool for measuring the impact of publications across various disciplines, including orthopedics. Previous research has utilized citation frequency to identify influential articles on PRP use, but there

is a lack of bibliometric analysis specifically focused on the therapeutic approach of PRP in the treatment of shoulder and elbow pathologies (Cash et al. 2022; Coulange Zavarro et al. 2022).

The purpose of this study is to identify the 50 most frequently cited orthopedic articles related to PRP use for shoulder and elbow pathologies. The journal of publication, trends in publication year, and authorship of the top 50 most-cited articles will also be examined. Identifying and quantifying these highly cited articles will serve as a useful resource for orthopedic surgeons and researchers to stay up to date in the rapidly evolving field of orthobiologic research. We hypothesize that year of publication will have a significant impact on the total number of citations achieved by an article.

METHODS

Institutional review board approval was not required given the public availability of the data. The Clarivate Analytics Web of Science database was used to perform this analysis using methods similar to those utilized in previous orthopedic bibliometric analyses (Cash et al. 2022; Coulange Zavarro et al. 2022; Gross et al. 2023; Moore et al. 2021; Namdari et al. 2012; Barbera et al. 2020). On 16 May 2023, several queries using different Boolean combinations were used to determine the broadest possible search that returned the greatest number of publications regarding the use PRP for shoulder and elbow pathologies within the Web of Science database. The following search was successful in obtaining the article and citation data used in this study: (TOPIC: (Platelet-rich Plasma OR PRP)) AND (TOPIC: (Shoulder OR Rotator Cuff OR Elbow)). There were no restrictions placed on the original language, journal, publication date, or country of origin, and no additional filters were utilized to complete this search.

The publications were then sorted by the number of citations from most-cited to least-cited. Titles and abstracts were reviewed by three authors to identify articles that were unrelated to the use of PRP in the treatment of shoulder and elbow pathologies and these studies were excluded. If a publication was a systematic review, a cadaveric study, did not use human subjects, a basic science study, only briefly mentioned PRP, only included a small number or percentage of shoulder or elbow patients, or if PRP was not the main focus of the article, then the article was excluded from the study. For example, a study discussing the use of PRP for chronic tendinopathy was excluded due to a lack of patients receiving PRP for shoulder and elbow pathologies and its extensive analysis of PRP for Achilles and patellar tendon pathologies (de Jonge et al. 2011). Similar to inclusion criteria in previously conducted analyses, articles that presented information on indication for PRP use, procedural descriptions, techniques, as well as outcomes following the application of PRP for shoulder and elbow pathologies were included (Cash et al. 2022; Coulange Zavarro et al. 2022; Gross et al. 2023; Barbera et al. 2020; Namdari et al. 2012; Moore et al. 2021; Cash et al. 2022; Gross et al. 2023; Coulange Zavarro et al. 2022; Moore et al. 2021). If there remained uncertainty with a specific publication after the initial screening process, the full article was reviewed by an additional author to determine whether the publication met the predetermined inclusion criteria.

RESULTS

The final search yielded 1440 publications. Of the resulting articles, the top 239 in terms of total number of citations were reviewed to identify the Top-50 publications that focused mainly on the use of PRP in shoulder and elbow pathology. The resulting list of 50 publications can be considered the Top-50 publications pertaining to the usage of platelet rich plasma (PRP) in shoulder or elbow pathology (**Table 1**). Each of the top 50 articles were published between 2006 and 2019, with a large increase in the number of publications in 2010 following FDA approval of PRP in 2009. Only 4 articles were published prior to 2010 including the overall most-cited paper (Mishra et al. 2014), which was published in 2006. The year with the most total citations amassed across the top 50 articles was 2011 with 1707, followed by 2013 and 2006 with 1254 citations and 561 citations respectively. Many of the total citations (3463), as well as nearly half of the total number of publications (22) came between the years 2011 and 2013 (**Figure 1**).

At the time of data collection, the total number of citations amassed by the top 50 articles was calculated to be 6318 with an average of 526.5 total citations per year and an average of 126.36 citations per publication. The most highly cited article was cited a total of 561 times (Mishra and Pavelko 2006), followed by publications with 459 (Peerbooms et al. 2010) and 335 (Gosens et al. 2011) citations respectively (Peerbooms et al. 2010; Gosens et al. 2011; Mishra and Pavelko 2006). The least cited articles received 38 (Raeissadat et al. 2014) and 39 (Schwitzguebel et al. 2019) citations, exactly 523 less citations than the most prolifically cited article. The top 50 articles were also analyzed on the basis of citation density, or the number of citations per the number of years since publication. The study by Peerbooms et al was the second most prolific article in terms of total citations (459) but the single highest in terms of citation density (35.3 citations/year) (Peerbooms et al. 2010). The study from Mishra et al. was the leader in total citations (561) but second in terms of citation density (33 citations per year) and is notably the earliest-published study included in this list (Mishra and Pavelko 2006).

The top 50 publications were next evaluated based on study design and level of evidence. Randomized controlled trials were the most prevalent among the included articles, comprising 29 of the top 50 publications, followed by cohort studies, case series, and case-control studies, which represented 13, 5, and 3 of the top 50 publications respectively (**Table 2**). It was noted that all randomized controlled trials included in this analysis were published during or after the year 2014, and all 8 of the articles published before 2010 were case series. The level of evidence of each of the top 50 publications was also recorded (**Figure 2**). Studies of Level I evidence composed more than half of the top 50 publications, occupying 26 spots on this list. Following be-

Table 1. The top 50 most-cited articles in platelet-rich plasma for shoulder and elbow treatment.

Rank	Article	Number of citations	Citation density
1	Treatment of chronic elbow tendinosis with buffered platelet-rich plasma	561	33.0
2	Positive Effect of an Autologous Platelet Concentrate in Lateral Epicondylitis in a Double-Blind Randomized Controlled Trial Platelet-Rich Plasma Versus Corticosteroid Injection With a 1-Year Follow-up	459	35.3
3	Ongoing Positive Effect of Platelet-Rich Plasma Versus Corticosteroid Injection in Lateral Epicondylitis A Double-Blind Randomized Controlled Trial With 2-year Follow-up	335	27.9
4	Platelet-Rich Plasma Augmentation for Arthroscopic Rotator Cuff Repair A Randomized Controlled Trial	327	27.3
5	Platelet rich plasma in arthroscopic rotator cuff repair: a prospective RCT study, 2-year follow-up	289	24.1
6	Efficacy of Platelet-Rich Plasma for Chronic Tennis Elbow A Double-Blind, Prospective, Multicenter, Randomized Controlled Trial of 230 Patients	230	25.6
7	The Effect of Platelet-Rich Fibrin Matrix on Rotator Cuff Tendon Healing A Prospective, Randomized Clinical Study	225	20.5
8	Platelet-Rich Plasma Versus Autologous Whole Blood for the Treatment of Chronic Lateral Elbow Epicondylitis A Randomized Controlled Clinical Trial	224	18.7
9	Treatment of Lateral Epicondylitis With Platelet-Rich Plasma, Glucocorticoid, or Saline A Randomized, Double-Blind, Placebo-Controlled Trial	222	22.2
10	Growth factor-based therapies provide additional benefit beyond physical therapy in resistant elbow tendinopathy: a prospective, single-blind, randomised trial of autologous blood injections versus platelet-rich plasma injections	185	15.4
11	Comparison of the therapeutic effects of ultrasound-guided platelet-rich plasma injection and dry needling in rotator cuff disease: a randomized controlled trial	176	17.6
12	Platelet-Rich Plasma Injections in the Treatment of Chronic Rotator Cuff Tendinopathy A Randomized Controlled Trial With 1-Year Follow-up	172	17.2
13	Does Platelet-Rich Plasma Accelerate Recovery After Rotator Cuff Repair? A Prospective Cohort Study	153	12.8
14	Rotator Cuff Repair Healing Influenced by Platelet-Rich Plasma Construct Augmentation	143	11.9
15	Platelet-Rich Fibrin Matrix in the Management of Arthroscopic Repair of the Rotator Cuff A Prospective, Randomized, Double-Blinded Study	140	14.0
16	Autologous platelet rich plasma for arthroscopic rotator cuff repair. A pilot study	140	9.3
17	Platelet-Rich Plasma for Arthroscopic Repair of Large to Massive Rotator Cuff Tears A Randomized, Single-Blind, Parallel-Group Trial	139	13.9
18	Treatment of Partial Ulnar Collateral Ligament Tears in the Elbow With Platelet-Rich Plasma	123	12.3
19	Use of Platelet-Leukocyte Membrane in Arthroscopic Repair of Large Rotator Cuff Tears A Prospective Randomized Study	115	10.5
20	Platelet-Rich Plasma in Rotator Cuff Repair A Prospective Randomized Study	111	12.3
21	Plasma Rich in Growth Factors in Arthroscopic Rotator Cuff Repair: A Randomized, Double-Blind, Controlled Clinical Trial	101	10.1
22	Exogenous application of platelet-leukocyte gel during open subacromial decompression contributes to improved patient outcome	100	6.7
23	Effects of Platelet-Rich Fibrin Matrix on Repair Integrity of At-Risk Rotator Cuff Tears	95	8.6
24	Platelet-rich plasma versus corticosteroid injection for recalcitrant lateral epicondylitis: clinical and ultrasonographic evaluation	94	11.8
25	Platelet-Rich Plasma for Arthroscopic Repair of Medium to Large Rotator Cuff Tears: A Randomized Controlled Trial	92	11.5
26	Subacromial injection of autologous platelet-rich plasma versus corticosteroid for the treatment of symptomatic partial rotator cuff tears.	88	12.6
27	Does application of moderately concentrated platelet-rich plasma improve clinical and structural outcome after arthroscopic repair of medium-sized to large rotator cuff tear? A randomized controlled trial	79	11.3
28	Do Postoperative Platelet-Rich Plasma Injections Accelerate Early Tendon Healing and Functional Recovery After Arthroscopic Supraspinatus Repair?: A Randomized Controlled	79	9.9

	Trial		
29	Does Pure Platelet-Rich Plasma Affect Postoperative Clinical Outcomes After Arthroscopic Rotator Cuff Repair?: A Randomized Controlled Trial	77	11.0
30	Platelet-rich fibrin in arthroscopic repair of massive rotator cuff tears : A prospective randomized pilot clinical trial	74	7.4
31	Local injection of autologous platelet rich plasma and corticosteroid in treatment of lateral epicondylitis and plantar fasciitis: Randomized clinical trial	67	6.1
32	Is Platelet-rich plasma superior to whole blood in the management of chronic tennis elbow: one year randomized clinical trial	63	7.0
33	Platelet-Rich Plasma Can Be Used to Successfully Treat Elbow Ulnar Collateral Ligament Insufficiency in High-Level Throwers.	58	8.3
34	Do blood growth factors offer additional benefit in refractory lateral epicondylitis? A prospective, randomized pilot trial of dry needling as a stand-alone procedure versus dry needling and autologous conditioned plasma	58	5.8
35	Inefficacy of ultrasound-guided local injections of autologous conditioned plasma for recent epicondylitis: results of a double-blind placebo-controlled randomized clinical trial with one-year follow-up	54	7.7
36	A Midterm Evaluation of Postoperative Platelet-Rich Plasma Injections on Arthroscopic Supraspinatus Repair	53	8.8
37	Does Autologous Leukocyte-Platelet-Rich Plasma Improve Tendon Healing in Arthroscopic Repair of Large or Massive Rotator Cuff Tears?	53	5.9
38	Platelet-Rich Plasma Injection With Arthroscopic Acromioplasty for Chronic Rotator Cuff Tendinopathy: A Randomized Controlled Trial	51	6.4
39	Platelet-rich plasma injection reduces pain in patients with recalcitrant epicondylitis.	51	4.3
40	Effectiveness of Platelet-rich Plasma Injection for Rotator Cuff Tendinopathy: A Prospective Open-label Study.	49	4.9
41	The effect of subacromial injections of autologous conditioned plasma versus cortisone for the treatment of symptomatic partial rotator cuff tears	45	6.4
42	Comparison of Local Injection of Platelet Rich Plasma and Corticosteroids in the Treatment of Lateral Epicondylitis of Humerus	45	5.6
43	Leukocyte-poor platelet-rich plasma versus bupivacaine for recalcitrant lateral epicondylar tendinopathy	44	5.5
44	Sodium Hyaluronate and Platelet-Rich Plasma for Partial-Thickness Rotator Cuff Tears	41	10.3
45	SECEC Research Grant 2008 II: Use of platelet- and leucocyte-rich fibrin (L-PRF) does not affect late rotator cuff tendon healing: a prospective randomized controlled study	41	5.9
46	Clinical and Structural Evaluations of Rotator Cuff Repair With and Without Added Platelet-Rich Plasma at 5-Year Follow-up: A Prospective Randomized Study	40	8.0
47	Effects of platelet-rich plasma on lateral epicondylitis of the elbow: prospective randomized controlled trial.	40	5.7
48	A randomized study of autologous conditioned plasma and steroid injections in the treatment of lateral epicondylitis	40	5.0
49	Efficacy of Platelet-Rich Plasma for the Treatment of Interstitial Supraspinatus Tears: A Double-Blinded, Randomized Controlled Trial	39	9.8
50	Effect of Platelet-Rich Plasma (PRP) versus Autologous Whole Blood on Pain and Function Improvement in Tennis Elbow: A Randomized Clinical Trial	38	4.2

hind were studies of Level II (14) evidence and a small number of both Level III (5) and Level IV studies (5). The Level I studies achieved the highest average citation density with an average of 13.95 citations per year per study, followed by the Level II studies, Level III studies, and finally Level IV studies with 12.33, 7.91, and 7.81 citations per year per study respectively.

The top 50 articles were published in a total of 19 unique journals (**Table 3**). The *American Journal of Sports Medicine* was the most prolific in terms of total publications produced, publishing 22 of the top 50 cited articles. *Arthroscopy*, the *Journal of Shoulder and Elbow Surgery*, and the *Journal of Orthopaedic Surgery* each published multiple articles included on this list, and no other journal included in this analysis published more than 1 of the Top-50 articles. Furthermore, these 50 articles originated from 17 different countries (**Table 4**), with authors from the United States contributing the highest number of publications (10), followed by England (5), India (4), and South Korea (4). Only 1 of the articles originating from the United States was published before the year 2010 (Mishra and Pavelko 2006), with all but one of the remaining American articles being published before in 2013 or before.

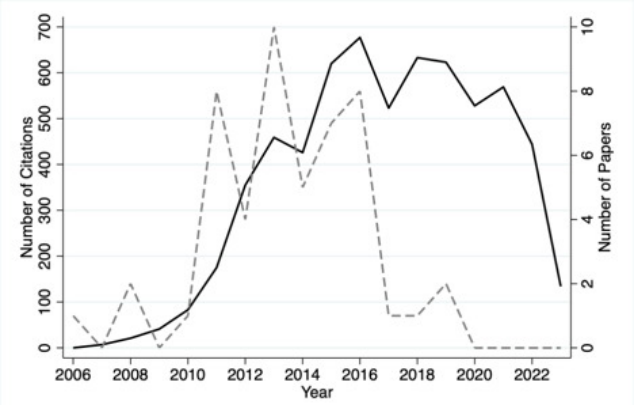

Figure 1. Total number of citations and publications per year

Table 2. Study Designs.

Study Type	Number of articles
Randomized controlled trial	29
Cohort study	13
Case-series	5
Case Control	3

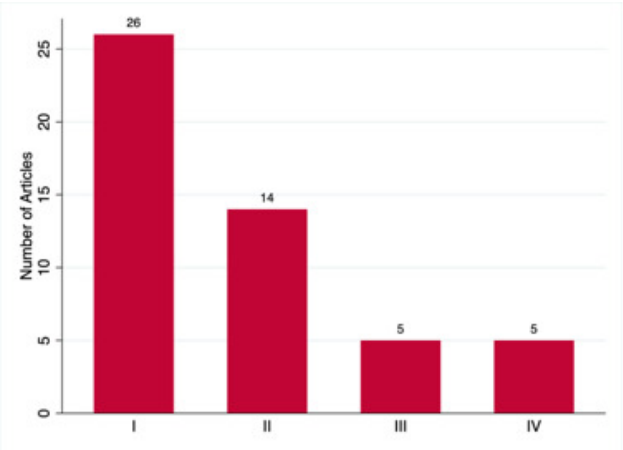

Figure 2. Level of evidence.

DISCUSSION

Platelet-rich-plasma is an autologous blood concentration containing high numbers of platelets that was originally introduced in the field of maxillofacial surgery dating back to the 1980s (Hall et al. 2009). Since introduction to musculoskeletal medicine, the use of PRP in clinical practice has remained controversial. In a study by Carr *et al.* in which the authors summarize the evidence surrounding many of the current orthopedic applications of PRP, the authors concluded that although in vitro studies of PRP have demonstrated success in influencing myocyte and tenocyte proliferation and matrix synthesis, clinical studies have not been quite as successful in establishing bona-fide evidence

Table 3. Number of publications by journal of origin.

Journal	Number of articles
American Journal of Sports Medicine	22
Arthroscopy	3
Journal of Shoulder and Elbow Surgery	3
Journal of Orthopaedic Surgery	2
Acta Orthopaedica Belgica	1
American Journal of Orthopedics	1
BMC Sports Science Medicine and Rehabilitation	1
British Journal of Sports Medicine	1
Clinical Rehabilitation	1
Disability and Rehabilitation	1
Egyptian Rheumatologist	1
European Journal of Orthopaedic Surgery & Traumatology	1
European Surgical Research	1
Global Advances in Health and Medicine	1
International Orthopaedics	1
Journal of Bone and Joint Surgery - *American Volume*	1
Journal of Clinical and Diagnostic Research	1
Knee Surgery Sports Traumatology Arthroscopy	1
Medicine and Science in Sports and Exercise	1
Orthopedics	1
Pain Research and Treatment	1
Revista Brasileira de Ortopedia	1
Rheumatology	1
Skeletal Radiology	1

in favor of the use of PRP as a nonoperative substitute for corticosteroid injections or as an augmentation to arthroscopic rotator cuff repair (RCR) due to largely heterogeneous results. (Carr and Rodeo 2019) While evidence that supports the clinical use of PRP may not be entirely conclusive, there remains optimism amongst the orthopedic community that biologic agents improving tendon and muscle healing in the treatment of debilitating upper extremity conditions may soon demonstrate reproducible clinical viability (Cash et al. 2022). Thus, PRP remains a massive area of interest among orthobiologic research, and it is important for studies such as this to orient readers to the history, innovation, and evidence that governs the use of orthobiologic agents such as PRP.

PRP has been investigated as a potential treatment for a variety of shoulder and elbow pathologies, leading to the development of a broad body of literature in this field. The main focuses of this set of publications were variable, with 27 articles focusing on the use of PRP in RCR, 18 focusing on PRP as a treatment for lateral epicondylitis and other elbow tendinopathies, 3 focusing on PRP use in rotator cuff

Table 4. Country of Origin

Country	Number of Articles
United States	10
England	5
India	4
South Korea	4
Brazil	3
France	3
Netherlands	3
Switzerland	3
Australia	2
Egypt	2
Italy	2
Spain	2
China	1
Denmark	1
Greece	1
Poland	1
Turkey	1

disease, and 2 focusing on PRP for ulnar collateral ligament insufficiency. In terms of overall number of citations, the top 3 articles, as well as 7 of the top 10, were found to focus on the application of PRP to treat debilitating elbow tendinopathies and lateral epicondylitis. The same three articles (Peerbooms et al. 2010; Mishra et al. 2014; Gosens et al. 2011) were also the top 3 in terms of citation density, comprising 6 of the top 10 in terms of this time-dependent metric. Of these publications, all but 1 (Creaney et al. 2011) report significant reduction in pain and improved elbow function after PRP administration (Mishra and Pavelko 2006; Peerbooms et al. 2010; Gosens et al. 2011; Mishra et al. 2014; Thanasas et al. 2011; Krogh et al. 2013; Creaney et al. 2011). Thus, the high prevalence of articles related to elbow tendinopathies within the top 10 suggests that the demonstrated utility of PRP in reducing pain and improving function in cases of elbow tendinopathies in the late 2000s and early 2010s represents a highly influential development within this body of literature, likely resulting in the sustained citation count observed among these articles year after year.

Examining the chronological distribution of these articles provides valuable insight into the time periods in which innovative research that influenced PRP research was performed. Of the included publications, only 3 were published in 2010 or before, with 2 of these papers originating from European authors (Mishra and Pavelko 2006; Randelli et al. 2008; Everts et al. 2008). The significant increases in the number of publications per year and prominence of American publications that was observed to occur in 2011 is consistent with other bibliographic analyses (Gross et al. 2023). This geographical and chronological distribution suggests that the early development of PRP may have been more prominent in Europe while the use of PRP in musculoskeletal medicine within the United States did not catch on until after 2010. However, US authors still published the most studies included on this list, with many of them emerging between 2011 and 2014. Of note, 27 of the top-50 papers in this study were focused on the use of PRP in shoulder arthroscopy, specifically arthroscopic rotator cuff repair (RCR). With 19 of these studies being published within the last decade, 55% (19 of 36) of the Top-50 articles in PRP published over that period of time are focused on the use of PRP in RCR patients, showing largely heterogeneous results. In the future, as methods surrounding intraoperative biologic augmentation of rotator cuff healing are further refined, perhaps a more focused evaluation of literature surrounding the use of PRP in conjunction with RCR will be able to orient readers to breakthroughs regarding this commonly performed procedure.

Level of evidence is an important consideration when evaluating research quality and reliability for applications in evidence-based medicine. In this study, a majority (55%) of the publications were randomized controlled trials of Level I evidence, suggesting that the scientific community is relying upon the highest-quality evidence available to guide research and apply PRP in clinical practice. This elevated proportion of studies with high levels of evidence contrasts those found in other orthopedic bibliographic analyses investigating joint arthroplasties, in which many articles in the Top 50 are of Level III and Level IV evidence (Barbera et al. 2020; Gross et al. 2023). With both surgical and non-surgical applications, PRP, and other orthobiologics for that matter, may be ideal modalities for the conduction of randomized controlled trials that could have resulted in the rapid maturation of this body of literature comparted to largely invasive procedures such as arthroplasty.

The number of citations an article achieves can further be influenced by the journal of publication and the country from which the article originates. Interestingly, nearly half (44%) of the included studies were published in the American Journal of Sports Medicine, one of the most prestigious journals in the field of orthopedic research. Thus, when examining the level of evidence and journal prestige of the articles analyzed in this study, it is quite possible that the large number of citations these articles received is due to their scientific merit and quality of evidence, and perhaps less likely to be affected by selection biases proposed in other bibliographic analyses (Gross et al. 2023). Furthermore, authors from the United States contributed most to these publications (20% of all papers), however we observed a smaller percentage of studies from American authors than in other bibliographic analyses (Cash et al. 2022; Gross et al. 2023; Namdari et al. 2012). While the definitive cause for prominence of US authorship in bibliographic analyses remains unclear, the inclusion of studies originating from 17 countries and 24 total journals around the globe makes it evident that the use of PRP upper extremity orthopedics is prevalent worldwide.

This study, as well as citation analyses in general, is associated with limitations. Most importantly, although the inclusion and exclusion criteria were based on previous orthopedics bibliographic analyses and were explicitly de-

fined for all reviewers prior to data collection, there remained some variability in article selection between authors. To combat this, multiple authors served as reviewers for each article, and if discrepancies between reviewers arose, an additional author was recruited to aid in the final decision such that inconsistencies within the selection process were minimized. Furthermore, the use of 50 publications in this analysis was arbitrary, as there were many articles that either had the same amount or were within only a few total citations from the least-cited articles included in this list. It is also possible that there may have been recently published articles that were omitted from this analysis that are quickly rising to prominence within this field, and thus the ranks of the publications on this list may soon become outdated. Lastly, as also described by previous bibliographic analyses, the total number of citations articles receive may not correlate directly with the quality of the content and evidence presented by the article. Specifically, the total number of citations of a particular publication may become inflated due to authors citing on the basis of higher citation count rather than the quality of the research being presented (Gross et al. 2023). However, the number of citations an article receives remains among the best metrics that can be used to evaluate the impact of an article over time despite its reception within its respective field.

CONCLUSION

Quantifying the top 50 most-cited articles within the vast body of literature for platelet-rich plasma in shoulder and elbow pathology may provide insight into the history, innovations, and future of the use of platelet-rich plasma as its clinical utility continues to be explored. Many of the current most-cited publications within this body of literature are randomized controlled studies that represent high levels of evidence and have been published since 2009, likely due to the recent rise in popularity of PRP within the field of orthopedic surgery. As the use of PRP grows and techniques continue to be refined, more randomized controlled studies are expected to rise to prominence as the clinical utility of PRP is evaluated for a wider variety of shoulder and elbow pathologies and surgical interventions. This may result in the opportunity for further specialized bibliographic analysis of the use of PRP for upper extremity pathologies.

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