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Systematic Review

The “Golden Age” of quadriceps tendon grafts for the anterior cruciate ligament: a bibliometric analysis



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ABSTRACT

Importance: Bibliometric research is a statistical analysis of publications to measure the scientific output in a specific field in order to highlight medical developments or knowledge gaps and to direct future scientific research. The quantity of orthopedic papers on the internet is astounding and is steadily growing as a result of recent advancements in technology and medicine. This is why choosing the right information is essential.

Aim: The purpose of this study was to analyze the current literature for trends in publications regarding quadriceps tendon (QT) grafting of the anterior cruciate ligament (ACL).

Evidence review: PubMed was searched on August 28, 2023. References were collected from PubMed, and trends were analyzed using this information. This search retrieved 405 articles regarding human and animal studies. We analyzed the top 10 authors and journals in terms of publication numbers, citation numbers, and citations per year. The PubMed-by-year feature was used to compare the number of publications regarding ACL reconstruction by quadriceps grafting with all publications in PubMed.

Findings: The number of yearly publications averaged 10 or less up to 2018, starting from 1982 when the first paper on the QT was published. However, the number of publications increased from 2018. While the total number of publications on this topic was 405, 260 were published from 2018 alone. The number of citations was 8262 in total overall years. It is expected that the last five years' publications, especially those for the last year, will be low in number, as it takes time for citations to accrue. The journal *Arthroscopy* published the most articles on this topic, with 57 papers and 1884 citations, followed by the *American Journal of Sports Medicine*, with 39 articles and 1576 citations. The top three journals on this topic were *Arthroscopy*, *American Journal of Sports Medicine*, and *Knee Surgery, Sports Traumatology, Arthroscopy*. The most published author was Musahl V (with 24 articles), and the most cited author was Xerogeaneas JW (with 570 citations).

Conclusions and relevance: Global trend analysis suggests that research on anterior cruciate ligament reconstruction with the quadriceps has significantly increased in the last 5 years and that the number of papers on this topic is increasing steadily. We found that the publications and citations are exhibiting a rising trend, *Arthroscopy* is the most impactful journal, and Musahl V is the most impactful author on the topic. Xerogeaneas JW is the author with the most citations on the topic. The promising clinical results of anterior cruciate ligament reconstruction with the QT have attracted the most research interest.

Level of Evidence: Level IV.

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What is already known

- Quadriceps Tendon autograft shows superior anatomical and biomechanical characteristics when compared to other autograft options that have been traditionally utilized.
- The quantity of orthopedic papers on the internet is astounding and is steadily growing as a result of recent advancements in technology and medicine.

What are the new findings?

- By utilizing a variety of indicators, including the impact factor and the H-index, bibliometric approaches assist in the quantitative evaluation of publications and are best known for their efforts to assess the importance of scientific research.
- These indicators are being used more frequently by reviewers and policy-makers to assess the impact of research since such analyses are more objective than peer reviews.
- Global trend analysis suggests that research on anterior cruciate ligament reconstruction with the quadriceps has significantly increased in the last 5 years and that the number of papers on this topic is increasing steadily.

INTRODUCTION

The occurrence of anterior cruciate ligament (ACL) rupture is prevalent among people who engage in physical activities, with an estimated yearly frequency of approximately 1 in 3500 individuals in the United States [1]. Due to ongoing and substantial research efforts and advancements in surgical techniques, ACL reconstruction (ACL-R) has gained widespread acceptance as the preferred treatment modality for ACL injuries in recent decades [2].

Currently, a range of autograft and allograft choices, such as hamstring (HT), bone patellar-tendon-bone (BPTB), quadriceps tendon (QT), and other alternatives, have been effectively employed in clinical and surgical practices for ACL-R [3]. The QT was initially proposed as a potential graft choice for ACL-R in the late 1970s [3]. However, its adoption was limited due to the initial emergence of several postoperative complications, such as elevated anterior laxity, weakness in the extensor mechanism, and positive pivot shift in approximately 20% of the treated cases [4]. Consequently, the utilization of the QT as a graft option for ACL-R did not gain widespread acceptance and was largely discontinued. However, it is not unexpected that these outcomes were observed, given that the initial treatments involved the extraction of a substantial segment of the QT, together with sections of the prepatellar retinaculum and patellar tendon, resulting in considerable soft tissue damage [4]. In recent decades, BPTB and HT autografts have consistently emerged as the predominant choices for grafting in ACL-R surgeries on a global scale [5]. Nevertheless, the resurgence of the QT in the clinical and research domains can be attributed to advancements in harvesting procedures and devices, coupled with notable enhancements in surgical techniques. These advancements have been accompanied by substantial research and a multitude of clinical studies, which have reported favorable outcomes [4]. Consequently, the QT is presently acknowledged as a feasible option for transplantation, offering a durable and mechanically advantageous graft. An increasing number of studies are providing evidence of the therapeutic potential and biomechanical features of QT autografts, highlighting their numerous benefits [4]. The rise in usage potential of the ACL Study organization has been acknowledged by experts in the field, leading to the establishment of the International Quadriceps Tendon Interest Group (IQTI) in 2017 [6]. The primary objective of this expert organization is to promote the adoption of the QT as a viable graft option. According to the findings of the 2018 study conducted by the IQTI expert group, it is advised to increase the frequency of employing QT autografts. This recommendation is based on the superior anatomical and biomechanical characteristics

exhibited by the QT autograft when compared to other autograft options that have been traditionally utilized [6].

Bibliometric research is a statistical analysis of publications to measure the scientific output in a specific field in order to highlight medical developments or knowledge gaps and to direct future scientific research. The quantity of orthopedic papers on the internet is astounding and is steadily growing as a result of recent advancements in technology and medicine. This is why choosing the right information is essential [7,8].

One bibliometric measure used to assess an article's scholarly effect is the quantity of citations it has received. While this does not equate to quality, it does show the degree of attention and impact an item has in a particular sector [7,8]. No previous bibliometric analysis of ACL-R with the quadriceps has been found, according to an examination of the current literature. Therefore, the purpose of this study was to analyze the trends of publications on anterior cruciate ligament reconstruction using the quadriceps as a graft in the current literature. We hypothesized that publications on this topic have quickly increased in recent years due to increased knowledge of both clinical and radiological pathology.

METHODS

The current bibliometric analysis follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. PubMed was searched on August 28, 2023 by two orthopedic surgeons experienced in knee surgery (SBK and RD) (Appendix 1) [9].

The references were collected from PubMed, and trends were analyzed using this information.

No time limit has been set for the bibliometric analysis. This retrieved 830 articles on human and animal studies. The bibliometric analysis encompassed solely those studies that examined the utilization of the quadriceps as a graft for ACL reconstructions leaving 405 articles for analysis.

A flow chart of the article selection process is presented in Fig. 1 [10].

We analyzed the top 10 authors and journals in terms of publication numbers, citation numbers, and citations per year. The PubMed-by-year feature was used to compare the number of publications on ACL reconstruction with the quadriceps with all publications in PubMed.

Data mining was performed using the Orange software, Mac version 3.32.0 (<https://orangedatamining.com/>), from the titles of all articles [11]. The output is presented as word clouds. Most of the analysis was

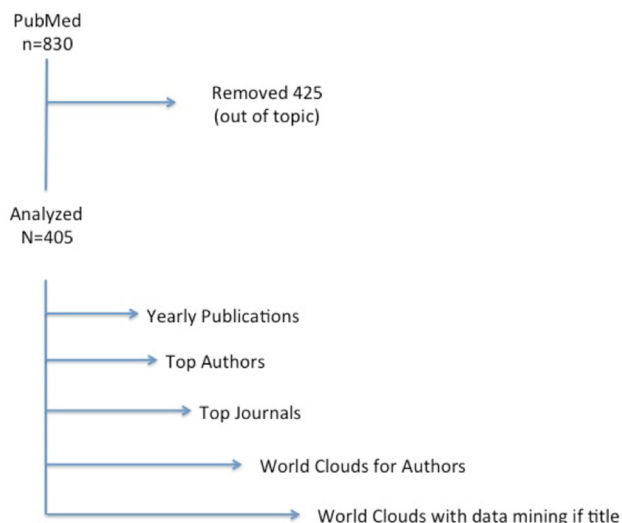


Fig. 1. PRISMA type chart of the analysis of articles and summary of the methodology.

performed using the output from PubMed (yearly publications, citations per publication, top authors, top journals). A word cloud analysis of titles from different periods (before 2017, after 2017, and journals before and after 2018) was performed. A word cloud analysis of the authors (before and after 2018) was also performed.

RESULTS

The number of yearly publications averaged 10 or less up to 2018 from 1982 when the first paper on the QT was published. However, the number of publications increased from 2018. While the total number of publications on this topic was 405, 260 were published from 2018 alone. This amounts to 64% of all publications in just the last six years. There has been a large surge in interest in this topic in recent years. The number of citations was 8262 in total over all years. It is expected that the last five years' publications, especially those for the last year, will be low in number, as it takes time for the citations to accrue. The maximum number of citations showed that the year interest in this topic started increasing in 2018 (Fig. 2).

The most cited article results to be “Vertical femoral tunnel placement results in rotational knee laxity after anterior cruciate ligament reconstruction,” published in 2007 in *Arthroscopy* with 187 citations. The 50 most cited articles are resumed in Table 1.

The number of citations of ACL-R with the quadriceps compared to all publications in PubMed, noting a precipitous rise from 2018 (Fig. 3).

The journal *Arthroscopy* published the most articles on this topic, with 57 papers and 1884 citations, followed by the *American Journal of Sports*

Medicine, with 39 articles and 1576 citations. The top three journals on this topic were *Arthroscopy: The Journal of Arthroscopic and Related Surgery*; *The American Journal of Sports Medicine*; and *Knee Surgery, Sports Traumatology, Arthroscopy*, official journal of the ESSKA (Fig. 4).

When we analyzed the number of citations per publication for the journals, *The Orthopedic Clinics of North America*, *The Journal of the American Academy of Orthopedic Surgeons* and *British Journal of Sports Medicine* were the top three journals, with 63, 56 and 50.5 citations per publication, respectively. Each of these journals had equal to or less than five publications published (Table 2).

There were a total of 1508 authors with 304 unique first authors. The most published author was Musahl V (with 24 articles), and the most cited author was Xerogeanes JW (with 570 citations). The top 10 authors arranged in order of the number of publications are given in Fig. 5. The top 10 authors by number of published articles and citations are given in the figure. Musahl V was the top published author, with 24 articles and 319 citations. Xerogeanes JW was the most cited, with 570 citations and 20 publications. The top three published authors included Musahl V, Xerogeanes JW, and Fink C.

Word clouds for titles, journals, and authors, including differences before and after 2018 for authors and titles, are given in Appendix 2 and Figures S1 to S5.

DISCUSSION

The main findings of our study reveal that there has been a steady growth in the number of publications regarding anterior cruciate ligament reconstruction using quadriceps grafting in the last 5 years (from 2018 to 2023), with an upsurge in publications. Our analysis demonstrated that *Arthroscopy: The Journal of Arthroscopic Related Surgery* is the most impactful journal and that Musahl V is the most impactful author on the topic of anterior cruciate ligament reconstruction using the quadriceps. Xerogeanes JW is currently the author with the most citations on the topic (570).

Currently, this is the first article in the literature to analyze PubMed in detail regarding publication trends and bibliometric data regarding anterior cruciate ligament reconstruction with the QT.

The reason why this tendon has experienced a resurgence in recent years is attributable to several and varied factors [6]. In ACL-R, QT autografts are significantly less prevalent than HT and BPTB grafts [12]. According to historical research, the QT autograft was linked to unacceptably high rates of residual rotatory knee laxity and quadriceps weakness, and it had worse biomechanical qualities than the native ACL [2]. The behavior of a “substitution” graft harvest approach, which entailed a thorough dissection of a 13 cm segment of extensor mechanism tissue made up of the QT, prepatellar retinaculum, and patellar tendon tissue, served as a major basis for these results [13]. Additionally, it was found that, in terms of ultimate load assessments, the graft obtained via the substitution procedure was 14%–21% weaker than the native ACL [2]. The substitute approach of autograft harvesting in ACL-R has been linked to a 20% rate of postoperative pivot shift. Significant quadriceps weakness is still linked to the substitute graft harvest procedure, especially in women. As a result, prior claims that the QT autograft was less effective in ACL-R were mostly supported by data from an out-of-date graft harvesting method [14].

Contemporary methods for harvesting QT autografts consistently provide a substantial amount of soft tissue while reducing the risk of donor site morbidity and/or deficiencies in quadriceps strength. Regarding the suitability of QT autografts for primary and revision knee ligament restoration, encouraging clinical data continue to come to light [14].

It is recommended to choose a graft based on individual characteristics in contemporary ACLR; there is no one graft that is suitable for all individuals. When selecting the most suitable graft for each patient, the surgeon must take into account several patient-specific, physician-specific, and graft-specific criteria. The factors to be taken into account are

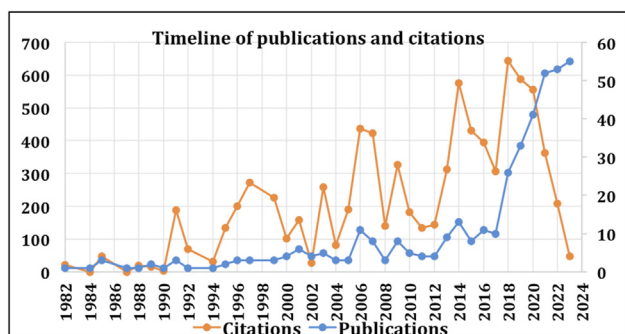


Fig. 2. Yearwise publications and citations on anterior cruciate ligament reconstruction with quadriceps tendon.

Table 1
Analysis of the 50 most cited articles.

S. No	Citations	Authors	Title	Citation	Level of evidence	Article type
1	187	Lee MC, Seong SC, Lee S, Chang CB, Park YK, Jo H, Kim CH.	Vertical femoral tunnel placement results in rotational knee laxity after anterior cruciate ligament reconstruction	Arthroscopy. 2007 Jul; 23(7):771–8. https://doi.org/10.1016/j.arthro.2007.04.016 .	III	Diagnostic Study
2	176	Stäubli HU, Schatzmann L, Brunner P, Rincón L, Nolte LP.	Mechanical tensile properties of the quadriceps tendon and patellar ligament in young adults	Am J Sports Med. 1999 Jan–Feb; 27(1):27–34. https://doi.org/10.1177/03635465990270011301 .	IV	Biomechanical Study
3	169	West RV, Harner CD.	Graft selection in anterior cruciate ligament reconstruction	J Am Acad Orthop Surg. 2005 May–Jun; 13(3):197–207. https://doi.org/10.5435/00124635-200505000-00006 .	IV	Review
4	161	Slone HS, Romine SE, Premkumar A, Xerogeanes JW.	Quadriceps tendon autograft for anterior cruciate ligament reconstruction: a comprehensive review of current literature and systematic review of clinical results	Arthroscopy. 2015 Mar; 31(3):541–54. https://doi.org/10.1016/j.arthro.2014.11.010 . Epub 2014 Dec 25.	III	Systematic Review
5	154	Howe JG, JohnsonRJ, KaplanMJ, FlemingB, JarvinenM.	Anterior cruciate ligament reconstruction using quadriceps patellar tendon graft. Part I. Long-term followup	Am J Sports Med. 1991 Sep–Oct; 19(5):447–57. https://doi.org/10.1177/036354659101900505 .	IV	Case Series
6	150	Mouarbes D, Menetrey J, Marot V, Courtot L, Berard E, Cavaignac E.	Anterior Cruciate Ligament Reconstruction: A Systematic Review and Meta-analysis of Outcomes for Quadriceps Tendon Autograft Versus Bone-Patellar Tendon-Bone and Hamstring-Tendon Autografts	Am J Sports Med. 2019 Dec; 47(14):3531–3540. https://doi.org/10.1177/0363546518825340 . Epub 2019 Feb 21.	II	Meta-analysis
7	141	Dejour D, Saffarini M, Demey G, Baverel L.	Tibial slope correction combined with second revision ACL produces good knee stability and prevents graft rupture	Knee Surg Sports Traumatol Arthrosc. 2015 Oct; 23(10):2846–52. https://doi.org/10.1007/s00167-015-3758-6 . Epub 2015 Aug 23.	III	Case Series
8	130	Nagarkatti DG, McKeon BP, Donahue BS, Fulkerson JP.	Mechanical evaluation of a soft tissue interference screw in free tendon anterior cruciate ligament graft fixation	Am J Sports Med. 2001 Jan–Feb; 29(1):67–71. https://doi.org/10.1177/03635465010290011601 .	IV	Biomechanical Study
9	128	Harris NL, Smith DA, Lamoreaux L, Purnell M.	Central quadriceps tendon for anterior cruciate ligament reconstruction. Part I: Morphometric and biomechanical evaluation	Am J Sports Med. 1997 Jan–Feb; 25(1):23–8. https://doi.org/10.1177/036354659702500105 .	IV	Biomechanical Study
10	127	Middleton KK, Hamilton T, Irrgang JJ, Karlsson J, Harner CD, Fu FH.	Anatomic anterior cruciate ligament (ACL) reconstruction: a global perspective. Part 1	Knee Surg Sports Traumatol Arthrosc. 2014 Jul; 22(7):1467–82. https://doi.org/10.1007/s00167-014-2846-3 . Epub 2014 Feb 5.	IV	Cross-sectional Study
11	127	LoI K, Kirkley A, Fowler PJ, Miniaci A.	The outcome of operatively treated anterior cruciate ligament disruptions in the skeletally immature child	Arthroscopy. 1997 Oct; 13(5):627–34. https://doi.org/10.1016/s0749-8063(9790191-2) .	IV	Case Series
12	121	Petersen W, Taheri P, Forkel P, Zantop T.	Return to play following ACL reconstruction: a systematic review about strength deficits	Arch Orthop Trauma Surg. 2014 Oct; 134(10):1417–28. https://doi.org/10.1007/s00402-014-1992-x . Epub 2014 Aug 5.	IV	Systematic Review
13	119	Fulkerson JP, Langeland R.	An alternative cruciate reconstruction graft: the central quadriceps tendon	Arthroscopy. 1995 Apr; 11(2):252–4. https://doi.org/10.1016/0749-8063(9590078-0) .	V	Case Report
14	111	Lund B, Nielsen T, Faunø P, Christiansen SE, Lind M.	Is quadriceps tendon a better graft choice than patellar tendon? A prospective randomized study	Arthroscopy. 2014 May; 30(5):593–8. https://doi.org/10.1016/j.arthro.2014.01.012 . Epub 2014 Mar 14.	II	Randomized Controlled Clinical Trial.
15	106	Han HS, Seong SC, Lee S, Lee MC.	Anterior cruciate ligament reconstruction: quadriceps versus patellar autograft	Clin Orthop Relat Res. 2008 Jan; 466(1):198–204. https://doi.org/10.1007/s11999-007-0015-4 . Epub 2008 Jan 3.	III	Therapeutic Study
16	105	Geib TM, Shelton WR, Phelps RA, Clark L.	Anterior cruciate ligament reconstruction using quadriceps tendon autograft: intermediate-term outcome	Arthroscopy. 2009 Dec; 25(12):1408–14. https://doi.org/10.1016/j.arthro.2009.06.004 .	IV	Therapeutic Case Series
17	105	Stäubli HU, Schatzmann L, Brunner P, Rincón L, Nolte LP.	Quadriceps tendon and patellar ligament: cryosectional anatomy and structural properties in young adults	Knee Surg Sports Traumatol Arthrosc. 1996; 4(2):100–10. https://doi.org/10.1007/BF01477262 .	IV	Biomechanical Study
18	104	Cavaignac E, Coulin B, Tscholl P, Nik Mohd Fatmy N, Duthon V, Menetrey J.	Is Quadriceps Tendon Autograft a Better Choice Than Hamstring Autograft for Anterior Cruciate Ligament Reconstruction? A Comparative Study With a Mean Follow-up of 3.6 Years	Am J Sports Med. 2017 May; 45(6):1326–1332. https://doi.org/10.1177/0363546516688665 . Epub 2017 Mar 8.	III	Comparative Study

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Table 1 (continued)

S. No	Citations	Authors	Title	Citation	Level of evidence	Article type
19	101	Reinhardt KR, Hetsroni I, Marx RG.	Graft selection for anterior cruciate ligament reconstruction: a level I systematic review comparing failure rates and functional outcomes	Orthop Clin North Am. 2010 Apr; 41(2):249–62. https://doi.org/10.1016/j.joc.2009.12.009 .	I	Systematic Review
20	90	Tan SH, Lau BP, Khin LW, Lingaraj K.	The Importance of Patient Sex in the Outcomes of Anterior Cruciate Ligament Reconstructions: A Systematic Review and Meta-analysis	Am J Sports Med. 2016 Jan; 44(1):242–54. https://doi.org/10.1177/0363546515573008 . Epub 2015 Mar 23.	IV	Systematic Review and Meta-analysis
21	87	Shelton WR, Fagan BC.	Autografts commonly used in anterior cruciate ligament reconstruction	J Am Acad Orthop Surg. 2011 May; 19(5):259–64. https://doi.org/10.5435/00124635-201105000-00003 .	IV	Review
22	83	Shani RH, Umpierrez E, Nasert M, Hiza EA, Xerogeanes JW.	Biomechanical Comparison of Quadriceps and Patellar Tendon Grafts in Anterior Cruciate Ligament Reconstruction	Arthroscopy. 2016 Jan; 32(1):71–5. https://doi.org/10.1016/j.arthro.2015.06.051 . Epub 2015 Sep 14.	IV	Biomechanical Study
23	80	Gobbi A, Mahajan S, Zanazzo M, Tuy B.	Patellar tendon versus quadrupled bone-semitendinosus anterior cruciate ligament reconstruction: a prospective clinical investigation in athletes	Arthroscopy. 2003 Jul–Aug; 19(6):592–601. https://doi.org/10.1016/s0749-8063(0300393-1) .	II	Comparative Study
24	77	Kim SJ, Kumar P, Oh KS.	Anterior cruciate ligament reconstruction: autogenous quadriceps tendon-bone compared with bone-patellar tendon-bone grafts at 2-year follow-up	Arthroscopy. 2009 Feb; 25(2):137–44. https://doi.org/10.1016/j.arthro.2008.09.014 . Epub 2008 Nov 20.	II	Comparative Study
25	77	Paessler HH, Mastrokalos DS.	Anterior cruciate ligament reconstruction using semitendinosus and gracilis tendons, bone patellar tendon, or quadriceps tendon-graft with press-fit fixation without hardware. A new and innovative procedure	Orthop Clin North Am. 2003 Jan; 34(1):49–64. https://doi.org/10.1016/s0030-5898(0200070-6) .	IV	Review
26	75	Wilk KE, Reinold MM, Hooks TR.	Recent advances in the rehabilitation of isolated and combined anterior cruciate ligament injuries	Orthop Clin North Am. 2003 Jan; 34(1):107–37. https://doi.org/10.1016/s0030-5898(0200064-0) .	IV	Review
27	74	Runer A, Wierer G, Herbst E, Hepperger C, Herbolt M, Gföller P, Hoser C, Fink C.	There is no difference between quadriceps- and hamstring tendon autografts in primary anterior cruciate ligament reconstruction: a 2-year patient-reported outcome study	Knee Surg Sports Traumatol Arthrosc. 2018 Feb; 26(2):605–614. https://doi.org/10.1007/s00167-017-4554-2 . Epub 2017 May 5.	III	Comparative Study
28	74	Petersen W, Zantop T.	Return to play following ACL reconstruction: survey among experienced arthroscopic surgeons (AGA instructors)	Arch Orthop Trauma Surg. 2013 Jul; 133(7):969–77. https://doi.org/10.1007/s00402-013-1746-1 . Epub 2013 Apr 21.	IV	Cross Sectional Study
29	70	De Angelis JP, Fulkerson JP.	Quadriceps tendon—a reliable alternative for reconstruction of the anterior cruciate ligament	Clin Sports Med. 2007 Oct; 26(4):587–96. https://doi.org/10.1016/j.csm.2007.06.005 .	IV	Review
30	69	Lee JK, Lee S, Lee MC.	Outcomes of Anatomic Anterior Cruciate Ligament Reconstruction: Bone-Quadriceps Tendon Graft Versus Double-Bundle Hamstring Tendon Graft	Am J Sports Med. 2016 Sep; 44(9):2323–9. https://doi.org/10.1177/0363546516650666 . Epub 2016 Jun 30.	III	Comparative Study
31	69	Gorschewsky O, Klakow A, Pütz A, Mahn H, Neumann W.	Clinical comparison of the autologous quadriceps tendon (BQT) and the autologous patella tendon (BPTB) for the reconstruction of the anterior cruciate ligament	Knee Surg Sports Traumatol Arthrosc. 2007 Nov; 15(11):1284–92. https://doi.org/10.1007/s00167-007-0371-3 . Epub 2007 Aug 25.	III	Comparative Study
32	69	Yasuda K, Ohkoshi Y, Tanabe Y, Kaneda K.	Quantitative evaluation of knee instability and muscle strength after anterior cruciate ligament reconstruction using patellar and quadriceps tendon	Am J Sports Med. 1992 Jul–Aug; 20(4):471–5. https://doi.org/10.1177/036354659202000420 .	IV	Case Series
33	68	Garofalo R, Djahangiri A, Siegrist O.	Revision anterior cruciate ligament reconstruction with quadriceps tendon-patellar bone autograft	Arthroscopy. 2006 Feb; 22(2):205–14. https://doi.org/10.1016/j.arthro.2005.08.045 .	IV	Case Series
34	63	Fischer F, Fink C, Herbst E, Hoser C, Hepperger C, Blank C, Gföller P.	Higher hamstring-to-quadriceps isokinetic strength ratio during the first post-operative months in patients with quadriceps tendon compared to hamstring tendon graft following ACL reconstruction	Knee Surg Sports Traumatol Arthrosc. 2018 Feb; 26(2):418–425. https://doi.org/10.1007/s00167-017-4522-x . Epub 2017 Mar 21.	III	Comparative Study
35	63	Ma Y, Murawski CD, Rahnama-Azar AA, Maldjian C, LynchAD, Fu FH.	Graft maturity of the reconstructed anterior cruciate ligament 6 months postoperatively: a magnetic resonance imaging evaluation of quadriceps tendon with bone block and hamstring tendon autografts	Knee Surg Sports Traumatol Arthrosc. 2015 Mar; 23(3):661–8. https://doi.org/10.1007/s00167-014-3302-0 . Epub 2014 Sep 16.	III	Comparative Study

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Table 1 (continued)

S. No	Citations	Authors	Title	Citation	Level of evidence	Article type
36	63	Xerogeanes JW, Mitchell PM, Karasev PA, Kolesov IA, Romine SE.	Anatomic and morphological evaluation of the quadriceps tendon using 3-dimensional magnetic resonance imaging reconstruction: applications for anterior cruciate ligament autograft choice and procurement	Am J Sports Med. 2013 Oct; 41(10):2392–9. https://doi.org/10.1177/0363546513496626 . Epub 2013 Jul 26.	III	Cross Sectional Study
37	60	Sheehan AJ, Musahl V, Slone HS, Xerogeanes JW, Milinkovic D, Fink C, Hoser C; International Quadriceps Tendon Interest Group.	Quadriceps tendon autograft for arthroscopic knee ligament reconstruction: use it now, use it often	Br J Sports Med. 2018 Jun; 52(11):698–701. https://doi.org/10.1136/bjsports-2017-098769 . Epub 2018 Apr 28.	IV	Review
38	60	Noyes FR, Barber-Westin SD.	Anterior cruciate ligament revision reconstruction: results using a quadriceps tendon-patellar bone autograft	Am J Sports Med. 2006 Apr; 34(4):553–64. https://doi.org/10.1177/0363546505281812 . Epub 2005 Dec 19.	IV	Case Series
39	59	Chen CH, Chuang TY, Wang KC, Chen WJ, Shih CH.	Arthroscopic anterior cruciate ligament reconstruction with quadriceps tendon autograft: clinical outcome in 4–7 years	Knee Surg Sports Traumatol Arthrosc. 2006 Nov; 14(11):1077–85. https://doi.org/10.1007/s00167-006-0111-0 . Epub 2006 Jun 24.	IV	Case Series
40	58	Kohl S, Stutz C, Decker S, Ziebarth K, Slongo T, Ahmad SS, Kohlhof H, Egli S, Zumstein M, Evangelopoulos DS.	Mid-term results of transphyseal anterior cruciate ligament reconstruction in children and adolescents	Knee. 2014 Jan; 21(1):80–5. https://doi.org/10.1016/j.knee.2013.07.004 . Epub 2013 Aug 21.	III	Case Series
41	57	Lee S, Seong SC, Jo CH, Han HS, An JH, Lee MC.	Anterior cruciate ligament reconstruction with use of autologous quadriceps tendon graft	J Bone Joint Surg Am. 2007 Oct; 89 Suppl 3:116–26. https://doi.org/10.2106/JBJS.G.00632 .	IV	Case Series
42	55	Lee S, Seong SC, Jo H, Park YK, Lee MC.	Outcome of anterior cruciate ligament reconstruction using quadriceps tendon autograft	Arthroscopy. 2004 Oct; 20(8):795–802. https://doi.org/10.1016/j.arthro.2004.06.009 .	IV	Case Series
43	53	Macaulay AA, Perfetti DC, Levine WN.	Anterior cruciate ligament graft choices	Sports Health. 2012 Jan; 4(1):63–8. https://doi.org/10.1177/1941738111409890 .	IV	Systematic Review
44	53	Mulford JS, Hutchinson SE, Hang JR.	Outcomes for primary anterior cruciate reconstruction with the quadriceps autograft: a systematic review	Knee Surg Sports Traumatol Arthrosc. 2013 Aug; 21(8):1882–8. https://doi.org/10.1007/s00167-012-2212-2 . Epub 2012 Sep 25.	IV	Systematic Review
45	53	Bizzini M, Gorelick M, Munzinger U, Drobny T.	Joint laxity and isokinetic thigh muscle strength characteristics after anterior cruciate ligament reconstruction: bone patellar tendon bone versus quadrupled hamstring autografts	Clin J Sport Med. 2006 Jan; 16(1):4–9. https://doi.org/10.1097/01.jsm.0000188040.97135.43 .	III	Comparative Study
46	51	Hurley ET, Calvo-Gurry M, Withers D, Farrington SK, Moran R, Moran CJ.	Quadriceps Tendon Autograft in Anterior Cruciate Ligament Reconstruction: A Systematic Review	Arthroscopy. 2018 May; 34(5):1690–1698. https://doi.org/10.1016/j.arthro.2018.01.046 . Epub 2018 Apr 5.	III	Systematic Review
47	51	Adams DJ, Mazzocca AD, Fulkerson JP.	Residual strength of the quadriceps versus patellar tendon after harvesting a central free tendon graft	Arthroscopy. 2006 Jan; 22(1):76–9. https://doi.org/10.1016/j.arthro.2005.10.015 .	IV	Biomechanical Study
48	51	Chen CH, Chen WJ, Shih CH.	Arthroscopic anterior cruciate ligament reconstruction with quadriceps tendon-patellar bone autograft	J Trauma. 1999 Apr; 46(4):678–82. https://doi.org/10.1097/00005373-199904000-00020 .	III	Cohort Study
49	51	Beynon BD, Johnson RJ.	Anterior cruciate ligament injury rehabilitation in athletes. Biomechanical considerations	Sports Med. 1996 Jul; 22(1):54–64. https://doi.org/10.2165/00007256-199622010-00005 .	V	Expert Opinion
50	48	Belk JW, Kraeutler MJ, Marshall HA, Goodrich JA, McCarty EC.	Quadriceps Tendon Autograft for Primary Anterior Cruciate Ligament Reconstruction: A Systematic Review of Comparative Studies With Minimum 2-Year Follow-Up	Arthroscopy. 2018 May; 34(5):1699–1707. https://doi.org/10.1016/j.arthro.2018.01.047 . Epub 2018 Apr 5.	III	Systematic Review

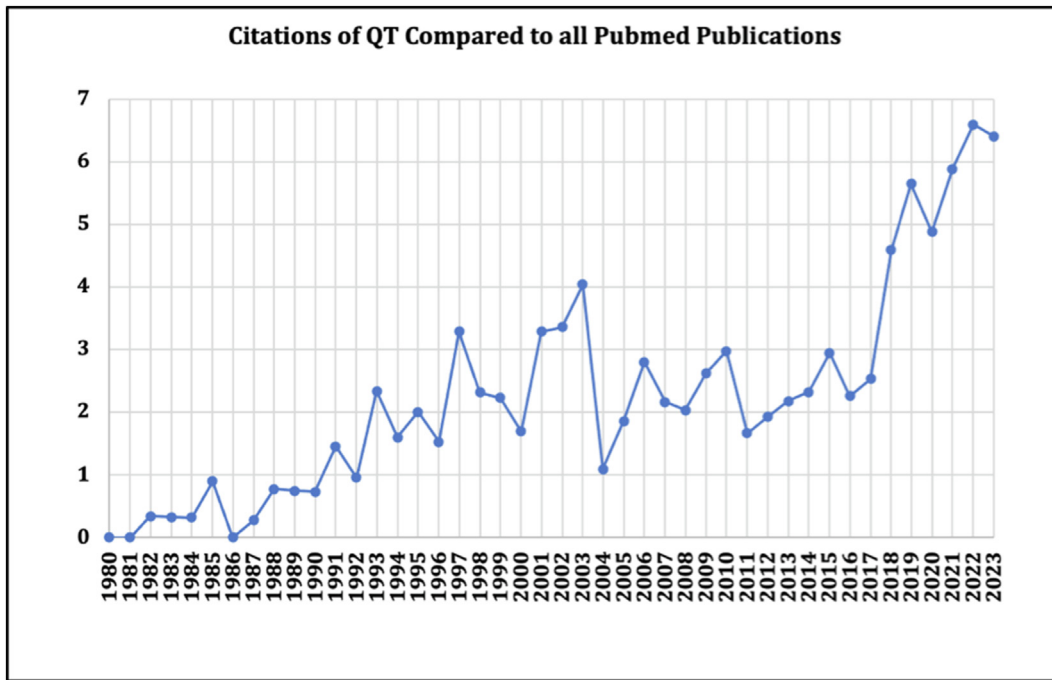


Fig. 3. The graph shows the number of citations for ACL-R using quadriceps graft, compared to all PubMed publications (per 100,000 PubMed publications) in Y axis, over the years in X axis.

the accessibility of tissue, any previous or simultaneous injury, the presence of other medical conditions in the patient, and the level of expertise of the surgeon. The ideal graft will provide a quick and efficient harvest with few complications, rapid integration into the body, and mechanical and structural characteristics that are comparable to the natural ACL. Nevertheless, each graft alternative possesses distinct anatomical and biomechanical features, leading to specific benefits and drawbacks [15].

Several recent clinical studies and reviews support the use of the QT as a primary graft choice [16–18].

Dai et al. in 2021 analyzed 7 RCTs and 17 observational studies for a total of 19,584, hypothesizing that QT had comparable graft survival as well as clinical function and pain outcomes with respect to HTs and bone-patellar-tendon-bone grafts. The authors concluded that the QT autograft

had comparable graft survival, functional outcomes, and stability outcomes compared with BPTB and HT autografts. However, donor site morbidity was significantly lower with QT autografts than with BPTB and HT autografts [19].

Similarly, Mourabes et al. performed a systematic review and meta-analysis and found that QT autografts had comparable clinical and functional outcomes and graft survival rates compared with BPTB and HT autografts. However, QT autografting resulted in significantly less harvest site pain than BPTB autografting and better functional outcome scores than HT autografting [15].

The “new life” application of the QT for ACL reconstruction not only involves primary ACL surgery but also concerns revision surgery, and the number of publications is increasing, supported by clinical studies. In fact, recently, Ashy et al. performed a systematic review and meta-

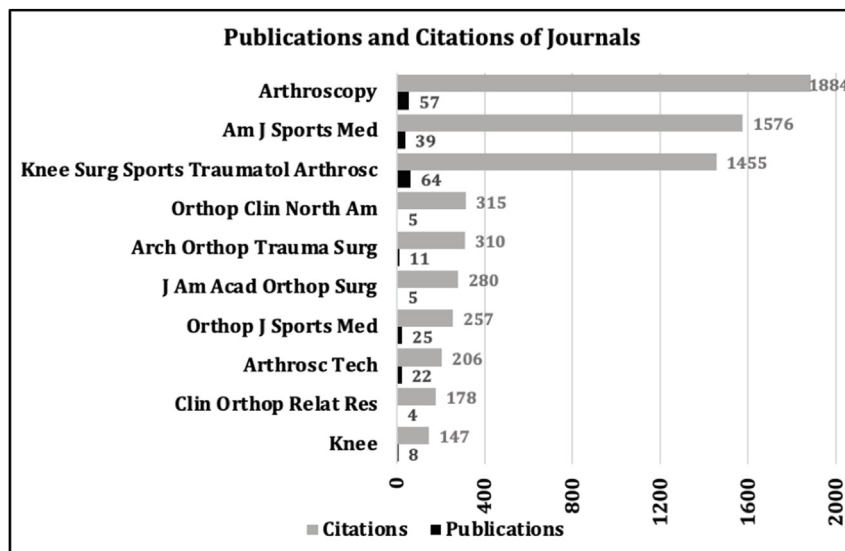


Fig. 4. Top ten journals for publications and citations.

Table 2
Top 10 journals arranged as per citations per publication for journals.

Journal	Publications	Citations	Citations/publication
Orthop Clin North Am	5	315	63
J Am Acad Orthop Surg	5	280	56
Br J Sports Med	2	101	50.5
Clin Orthop Relat Res	4	178	44.5
Am J Sports Med	39	1576	40.41
J Bone Joint Surg Am	3	115	38.33
Open Access J Sports Med	1	36	36
J Trauma	2	70	35
Sports Med	2	67	33.5
Arthroscopy	57	1884	33.05

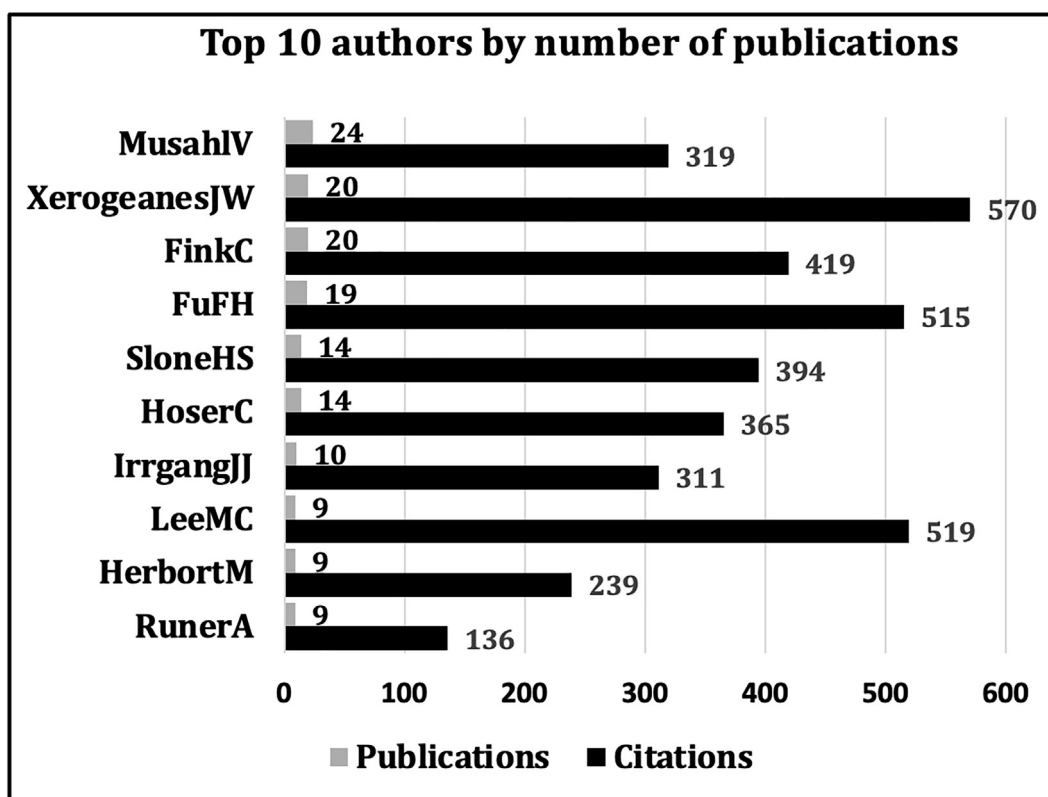
analysis of revision ACL-R (RACLR) with the QT and compared its patient outcomes to those of RACLR with HT and BTB autografts. RACLR with QT autografting yields satisfactory patient-reported outcomes, satisfactory improvement in knee laxity, and expected return to sport rates and has an overall 7.6% failure rate. Outcomes are comparable to those of the HT and BTB, making the QT an acceptable graft choice for RACLR [20].

One of the reasons this tendon was abandoned for years, scientifically and clinically, was due to the number of complications. It has been seen,

however, especially in recent years that these are negligible or at least comparable to those of other grafts.

Even though QT ACL-R results are similar, problems do occur and have been documented in a number of studies over the years. Thankfully, the majority of significant issues affect only a tiny proportion of patients, and the majority of complications are mild. These comprise the standard hazards of ACL-R that are related to any kind of transplant, such as graft failure, infection, and venous thromboembolism [6,14]. In contrast to BTB or HS ACL-R, Lind et al. discovered a much greater revision rate in the Danish Knee Ligament Registry after QT ACL-R. However, after more investigation, they found that the higher revision rate only occurred in centers that performed fewer than 100 procedures over an 8-year span. This highlights the fact that there is a learning curve for QT ACL-R and that, similar to many other surgical techniques, better results come with more practice [21,22].

The increasing trends of publications regarding ACL-R with the QT have also occurred because in the last ten years, there has been a sharp increase in publications worldwide [23]. This shows a significant growth in scientific interest in these minimally invasive techniques. Arthroscopic procedures enable a faster healing process after surgery, which enables patients to resume sporting and professional activities sooner than after



Author	Institution	Country
Musah V	University of Pittsburgh Medical Center	Pittsburgh, Pennsylvania, USA
Xerogeanes JW	Emory University	Atlanta, Georgia, USA
Fink C	Gelenkpunkt Sportsclinic	Innsbruck, Austria
Fu FH	University of Pittsburgh Medical Center	Pennsylvania, USA
Slone HS	Medical University of South Carolina	Charleston, South Carolina, USA
Hoser C	Gelenkpunkt Sportsclinic	Innsbruck, Austria
Irrgang JJ	University of Pittsburgh	Pittsburgh, Pennsylvania, USA
Lee MC	Seoul National University Hospital	Seoul, Republic of Korea
Herbort M	OCM Orthopedic Surgery Munich Clinic	Munich, Germany
Runer A	Klinikum Rechts der Isar, Technical University of Munich	Munich, Germany

Fig. 5. Top 10 first authors for publications.

conventional surgery. In addition to a general increase in the number of publications in medicine, the rising publication rate can be explained by, among other things, increasing technical and technological progress, resulting in increased procedural options and novel indications [24].

Bibliometric techniques are most known for their efforts to measure the significance of scientific research using many indicators, including the impact factor and the Hirsch (H)-index, and for their assistance in the quantitative evaluation of publications [25]. Due to their greater objectivity than that of peer reviews, reviewers and policy-makers are increasingly employing these indicators to assess the impact of research. However, assessors may employ bibliometric indicators erroneously due to a lack of clarity regarding their functionality [25]. The most common mistake is probably estimating an article's importance based only on its impact factor, which is inaccurate because only 10%–30% of papers published in journals receive the majority of the citations (also known as “skewed publications”) that journals use to determine their impact factor [25].

There are significant differences in citation counts between different topic fields; hence, it is incorrect to compare the impact factor or an author's H-index values between disciplines. The third common mistake assessors make is not taking time into account. Citations accumulate slowly at first, but they also continue to accumulate over time. Studies have shown that papers need to have received enough citations for two or three years after publication for bibliometric indicators to be reliable. This suggests that the most recent papers considered in any institutional evaluation, including bibliometric markers, should have been published no less than two years previously [26,27].

Regarding the impact of bibliometric analysis, a recent article examined a series of papers from top-ranked orthopedic journals with respect to the number of citations over a 10-year observation period to identify factors that lead to high citation rates and thereby identify what makes an orthopedic publication highly citable. The authors found a statistical correlation between the number of citations and the number of authors, number of keywords and number of references. In addition, the top 20% of papers showed a largely constant citation trend after two years for up to at least ten years. Randomized clinical trials (RCTs) and reviews are cited most frequently [28].

Our study presents some limitations. First, only terms from the titles were used for the analysis. This has the following drawback: if a term was not included in the title, the analysis would not incorporate it. Some data may be missing because standardizing the names of manuscripts—such as RCTs and systematic reviews—is a relatively new requirement that authors and publishers have not all followed consistently.

Veterinary journal publications were among the ones examined. Since the majority of fundamental science research on the ligament was conducted on animals and some of these articles may have been published in veterinary journals, we did not attempt to separate the veterinary literature. Our study relied on PubMed, which, similar to all bibliometric databases, is not exhaustive. For instance, PubMed does not show all the articles published in different databases (WoS or Scopus). Nevertheless, it is most commonly used and freely available.

We selected one of the most popular databases, but there is no single one that is unquestionably better. Since citations are a dynamic phenomenon, the articles and search results we found today represent the state of the field; a search conducted later may provide different results, or the quantity of citations may change.

Last, the quality and quantity of evidence in the papers is another constraint; even though a study is frequently mentioned, it may only be a level 5 paper.

Despite the abovementioned possible limitations, we believe the approach utilized in this study is appropriate for the type of research. Research trends and hotspots can be easily seen using bibliometrical and visual analysis. This can help figure out the best future directions for basic and clinical research and boost research skills in the field of ACL reconstruction.

Conclusions

Global trend analysis suggests that research on anterior cruciate ligament reconstruction with the QT has significantly increased in the last 5 years and that the number of papers on the topic is increasing steadily. We found that the publications and citations presented a rising trend: *Arthroscopy: The Journal of Arthroscopic and Related Surgery*, is the most impactful journal, and Musahl V is the most impactful author on the topic; Xerogeaneas JW is currently the author with the most citations on the topic. The promising clinical results of anterior cruciate ligament reconstruction with quadriceps have attracted the most research interest.

Ethical committee approval

Not needed, being a literature review and not involving any human intervention.

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Data availability

The raw data are available with us if needed.

Consent to participate

Not needed, being a bibliometric analysis and not involving any human intervention.

Consent to publish

All authors approved to publish the paper.

Code availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Professor Christian Fink, the Senior author of this paper, results as one of the top published authors within the article. This was not intentional and was simply the result of our analysis. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jisako.2024.03.007>.

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