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General

Tears, Tendons, and Trends: A Bibliometric Analysis on Anterior Cruciate Ligament Research

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This bibliometric analysis investigates global research trends in anterior cruciate ligament (ACL) injury prevention and treatment by evaluating 4,086 articles indexed in the Web of Science Core Collection from 1985 to June 18, 2025. The top funding agencies of ACL research showed governmental-linked institutions from the United States, the People's Republic of China, and Japan supporting a substantial part of ACL literature. Keyword emphasis on surgical methods was evident in the indexed literature on ACL. Continued research towards improving surgical methods will prevent retear, assist in more efficient recovery, and better long-term outcomes for the patient.

IMPACT STATEMENT

A bibliometric analysis examines connections, patterns, and impacts of academic publications quantitatively. This study assesses how the anterior cruciate ligament is being researched and analyzed for mechanisms of tearing and treatment methods, contributing to a better understanding of anterior cruciate ligament injury.

INTRODUCTION AND BACKGROUND

Anterior cruciate ligament (ACL) injury is one of the most common knee injuries, with annual cases reported to be 1 in 3,500 people, as of 2023.[1,2] The ACL is a crucial element of the body for knee stability. The ACL provides people with a natural prevention method to help leg deformation. ACL reconstruction (ACLR) is a surgical treatment for the majority of ACL injuries. For this study, ACL injury is defined as a partial or full tear of the ACL. ACL injury can be caused by continuous stress on the ligament (e.g., activity with repeated stressful movements) or an instantaneous stress (e.g., sudden hyperextension of the knee) that causes the tear. Female athletes have been observed to have approximately three times the rate of ACL tears as male athletes.[3] In athletes, movements without contact (e.g., changing directions hastily) have a higher incidence of ACL tears than contact interactions with other players.[4,5]

Depending on the patient's situation, ACL treatment can differ. Partial tears of the ACL have a greater variety of treatment options for patients, while full tears have relatively limited treatment options that generally always require surgical methods. ACLR is an option for all ACL injuries, but may not be required for partial tears. There are some commonly used treatments for ACL. Autografting is grafting from the patient's tissues. On the other hand, allografting is grafting from, in the context of human ACL repair, another human's tissues. Autografts are often preferred over allografts due to the lower risk of undesirable immune response and eliminate the risk of disease transmission from a donor. However, more recent research and innovation have found how to improve support for a reconstructed ACL. One of these innovations is the bridge-enhanced ACL repair (BEAR) implant that places a resorbable implant with an autologous blood injection in between the torn ends of the ACL during surgery to facilitate natural healing of the ACL.[6,7] Another innovation is InternalBrace ligament augmentation, which uses suture tape in surgery to take stress off the reconstructed ACL.[8,9] With a partial ACL tear, treatment can be performed with only non-surgical methods. These non-surgical methods are also used in later stages of full ACL tears, such as physical therapy, bracing, and walking aids for the patient. Partial ACL tears may only require these methods due to their ability to heal naturally compared to full ACL tears, which largely cannot.

Bibliometric analysis assists in translating the research field developed for ACL injury and treatment to showcase topic trends, organizations backing research, and publishing countries. This study intends to present the path of ACL injury and treatment research up to the present and how the direction may evolve going forward.

METHODS

Web of Science was utilized to gather data for this bibliometric analysis, which was then uploaded into VosViewer.[10] The search made in the database was as follows: TS = ((“ACL injury” OR “anterior cruciate ligament injury” OR “ACL” OR “anterior cruciate ligament”) AND (“allograft” OR “autograft” OR “bridge-enhanced a*” OR “physical therapy” OR “internal brace”) AND (“tendon” OR “patellar tendon” OR “quadricep tendon” OR “hamstring tendon”)).

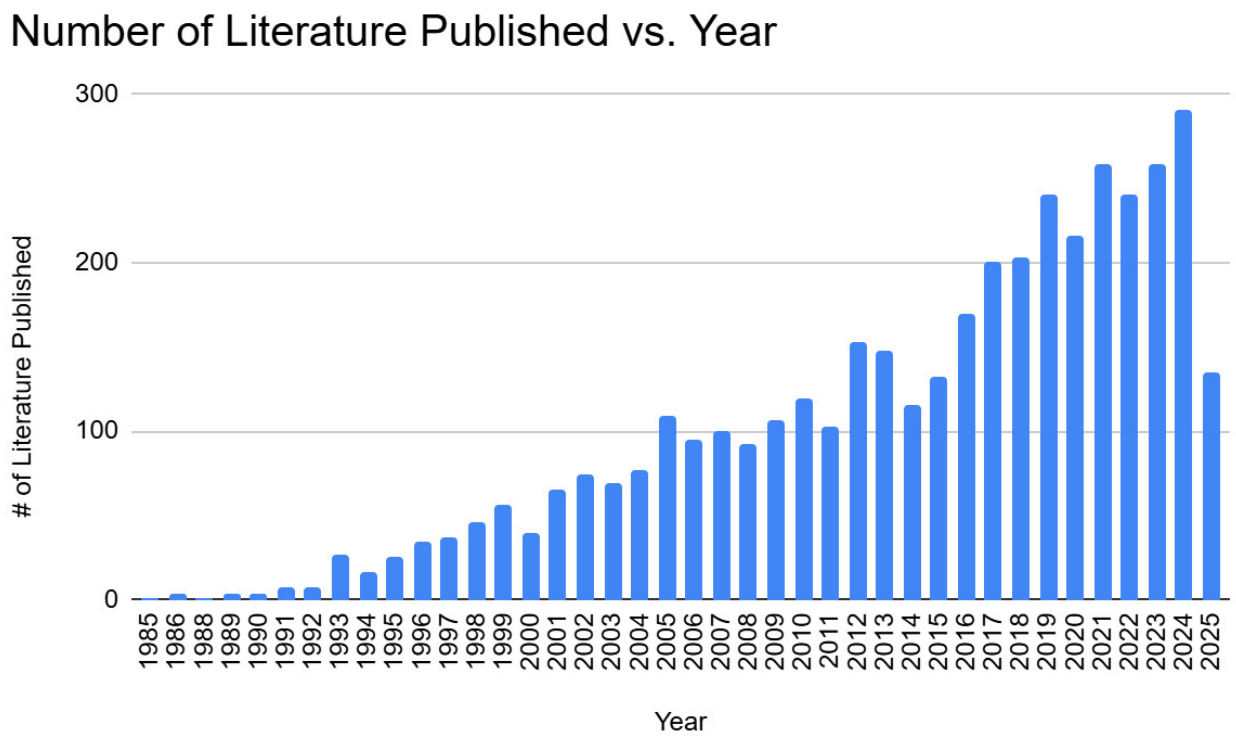

Figure 1. Number of publications per year on ACL injury and treatment.

RESULTS

In total, 4,086 articles were collected for evaluation. Publications on ACL injury and treatment were made from 1985 to the present (Figure 1).

Looking further at this bar graph also displays the trends between years. From 2013 to 2014, there was about a 21.6% drop in the number of articles published, with 148 being published in 2013 and 116 published in 2014. From 2019 to 2020, another drop of 10% in the number of articles published was observed. Overall, a gradual increase in literature published each year from 1985 is observed. The most recent peak was 291 literature published in 2024.

While exploring the agencies that are funding research into ACL injury and treatment, the United States Department of Health and Human Services (HHS) can be seen as the leading funding agency, with 531 articles funded. The HHS encompasses the National Institute of Health (NIH, a subdivision of the HHS) and the National Institute of Arthritis and Musculoskeletal and Skin Diseases (a subdivision of the NIH). Away from the U.S., in the leading agencies for funding, the National Natural Science Foundation of China has supported funding for 67 articles. ACL injury and treatment research has also been funded by agencies in Japan. Specifically, the Japan Society for the Promotion of Science and the Ministry of Education, Culture, Sports, Science, and Technology together funded 84 articles. There are some private companies that also provide substantial funding to ACL research. The two prominent private companies are Arthrex, which is based in the U.S., and Smith+Nephew, which is based in England. Arthrex and Smith+Nephew have supported funding for 98 and 66 pieces of literature, respectively (Figure 2).

From the analysis of ACL injury and treatment articles published by different countries in the bibliometric visualization, the U.S., the People's Republic of China, Germany, Japan, and Australia are the five countries with the largest number of publications in descending order (Figure 3).

By discerning the keywords related to ACL injury and treatment, the five that received the most usage are anterior cruciate ligament, with 1667 occurrences and link strength of 7195; acl reconstruction, with 1244 occurrences and link strength of 5717; autograft, with 1085 occurrences and link strength of 5163; patellar tendon, with 1018 occurrences and link strength of 4996; and knee, with 909 occurrences and link strength of 4560 (Figure 4).

DISCUSSION

Year by year, there is a general increasing trend in the number of publications for ACL injury and treatment. However, in 2013, the drop in research may be attributed to government sequestration in the U.S., which caused a $1.55 billion cut in funding towards the NIH.[11,12] Since the NIH was seen as the leading funding agency for ACL injury and treatment, many researchers who received their funding from them may have lost it. In 2020, the COVID-19 pandemic began to impact countries worldwide, necessitating a shift in funding and research towards COVID-19 prevention and treatment.[13,14] This may have caused a slight decrease in

Figure 2. Agencies that fund ACL injury and treatment.

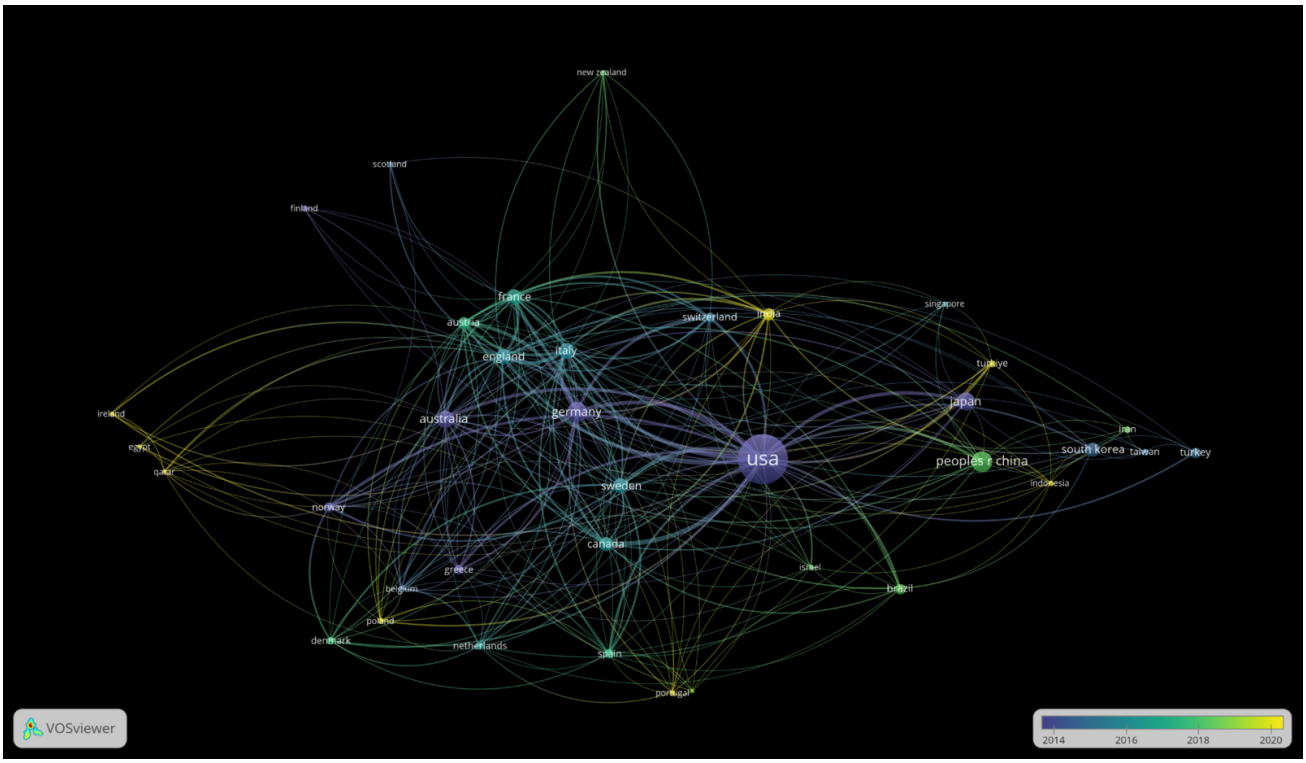

Figure 3. Countries that publish on ACL injury and treatment.

funding for ACL injury and treatment research as funding shifted to COVID-19. Arthrex, a private U.S.-based company, is the developer of the InternalBrace ligament augmentation. Thus, they may have been motivated to fund ACL research to expand the scope of their product. Moreover, the leading funding agencies from the U.S., the People's Republic of China, and Japan government-linked organizations correlate with them being among the largest numbers of publications in Figure 3.

The five most used keywords have high relevance to ACL injury and prevention. The anterior cruciate ligament is located within the patellar (knee) area and is most commonly torn compared to the posterior, medial, and lateral cruciate ligaments. Autografts being more favorable than allografts may explain the higher frequency of the keyword 'autograft'. Additionally, the high frequency of the keyword 'patellar tendon' can be correlated to the common use of the patellar tendon for autografts in ACLR.[15]

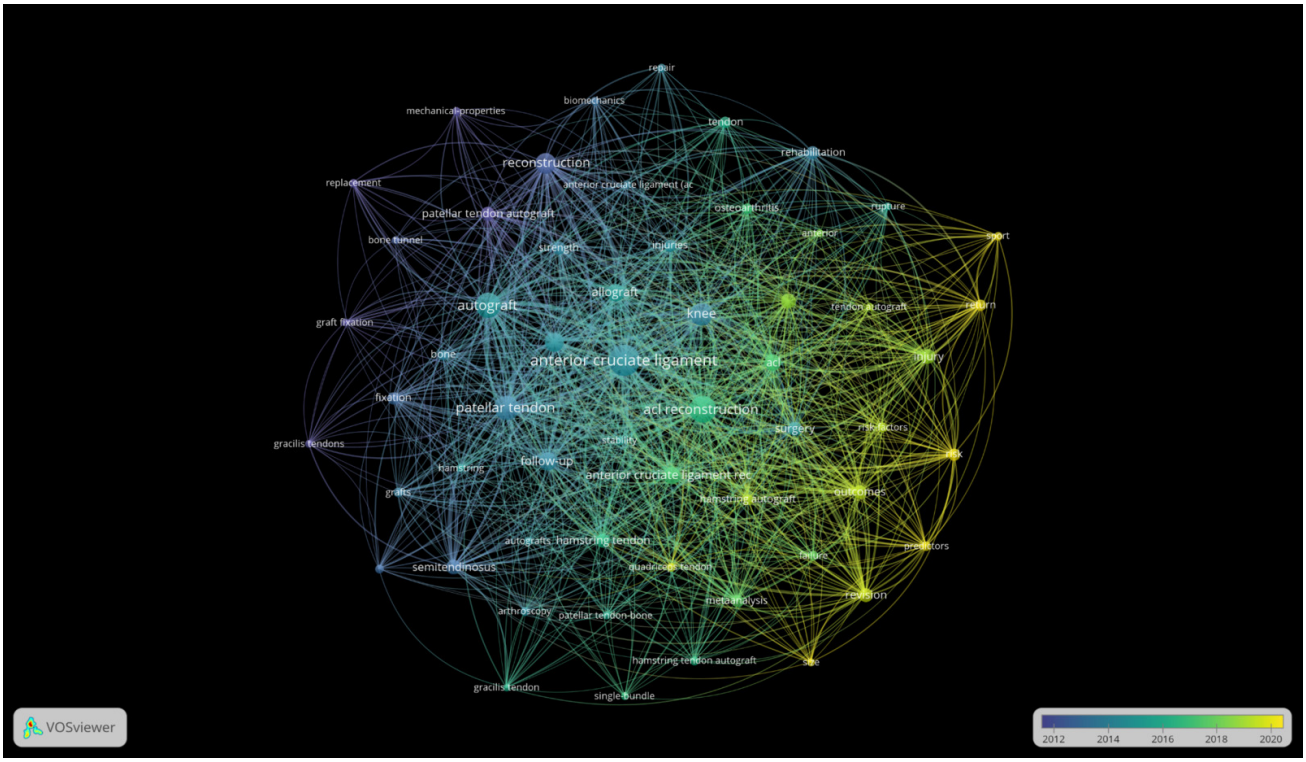

Figure 4. Most frequent keywords associated with ACL injury and treatment publications.

In surgical grafting for ACLR, other than the patellar tendon, more areas of the body can be grafted from. The hamstring and quadriceps tendons can be grafted for autografts and allografts. In allografts, the Achilles tendon can be used for grafting.[16] The Achilles tendon cannot be used in autografts because the full tendon with the bone block for fixation is taken from the deceased donor in allografting. If the Achilles tendon were to be used in autografting, the patient would no longer have support in the tarsal area, causing a new issue in treatment. In addition to autografts and allografts, xenografting from porcine tissue for ACLR has been used. Porcine tissue is utilized because of structural similarities between human and pig knees.[17] These grafting methods provide a wide range of options during ACLR and require more research on effectiveness across different cases in patients.

However, after ACLR, gait issues can occur due to the biomechanics of the patellar area joints shifting away from their original joint angles. Joint angles have been observed to change in flexion, extension, and adduction during daily walking activities.[18] These observations of biomechanical changes contribute to how the patient should be handled in non-surgical treatment (e.g., physical therapy exercises). Analyzing the muscle use of patients for improved ability to return to normal gait movement is important for the improvement of non-surgical treatment.[19] For example, faster walking has been noted to be directly related to negative patient outcomes in terms of gait symmetry.[20] Gait deficiencies may also cause an increased risk of ACL retear due to movements without contact being more common in cases of ACL tears. There could be an increased possibility of movements that put more stress on the ACL.

LIMITATIONS

The use of specific keywords may exclude literature with additional relevant topics. There is selection bias because only English keywords were vitalised, showing language bias, and are used to search in the Web of Science Core Collection database. Thus, the literature forming the quantitative bibliometric data for this study may have different citation data than in Google Scholar and Scopus, two respected databases.

CONCLUSIONS

Although this bibliometric analysis has limitations, the results show ACL-related research to have significant growth in the past four decades due to innovations in treatment techniques, especially surgical methods. Public and private investments have both contributed to the evolving ACL field in improving prevention, refining treatments, and reducing retear rates in patients with ACL injuries. Sustained funding for research and development must be present to continue expansion in the understanding of ACL pathophysiology.

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