Original Article

Patient Interest in Quadriceps Autograft Anterior Cruciate Ligament Reconstruction Is Increasing Over Other Autograft Options: A 12-Year Google Trends Analysis

Joseph C. Brinkman, M.D., M. Lane Moore, B.S., Cara Lai, M.D., Sailesh V. Tummala, M.D., Jordan R. Pollock, B.S., Kade S. McQuivey, M.D., Jeffrey D. Hassebrock, M.D., Adam B. Thompson, B.S., and Anikar Chhabra, M.D.

Purpose: To use Google trends to explore differences in public interest among types of anterior cruciate ligament (ACL) autografts, specifically quadriceps tendon, patellar tendon, and hamstring tendon autografts, between 2008 and 2019. **Methods:** Data were obtained by querying Google Trends for key terms and phrases for online search data ranging from January 2008 to December 2019. Relative search volumes were created based on searches related to ACL reconstruction with comparative analysis generated for search terms related to quadriceps ACL, patellar tendon ACL, and hamstring ACL autografts. Statistical analysis included linear regression analysis, comparison of quarterly search volume trends over time, and comparison of cumulative annual search volumes for 2008 versus 2019. **Results:** Linear models for respective search terms were statistically significant for the quadriceps ($P < .001$) and patellar ($P = .007$) tendon autograft groups but not the hamstring group ($P = .129$). The quadriceps autograft group demonstrated a 12-year search volume trend change of 0.56, which was significantly greater than the hamstring (0.07; $P < .001$) and patellar tendon (0.168; $P < .001$) groups. There was no significant difference in the trend change between hamstring and patellar tendon groups ($P = .20$). Percent change in cumulative relative annual search volumes between 2008 and 2019 was 112% for the quadriceps tendon group, 12.9% for the hamstring group, and 18.6% for the patellar tendon group. **Conclusions:** This study indicates a consistently increasing public interest in quadriceps tendon autograft for ACL reconstruction. The quadriceps autograft group demonstrated a significantly greater 12-year online search volume, greater linear correlation, and larger percent change between 2008 and 2019 compared with patellar tendon or hamstring autograft groups. **Clinical Relevance:** Awareness of patient perceptions has value in informing shared decision-making, aligning patient expectations, and guiding areas of future research. Each of these has an impact on patient care. Being aware of patient interest and expectations is particularly important in areas with controversial or emerging research.

Anterior cruciate ligament (ACL) tears represent the highest proportion of knee injuries and are one of the most common pathologies seen in orthopaedic sports medicine.[1,2] Among active patients, ACL reconstruction with autologous tissue is widely considered the treatment of choice for restoring stability to the knee and affording return to sport.[3,4] The decision to pursue surgery is a shared decision-making process that is patient dependent and considers several factors, including functional demand and concomitant pathology. For patients who do undergo surgery, several options for reconstruction exist, including quadriceps tendon autograft, patellar tendon (bone−patellar tendon−bone) autograft, and quadrupled hamstring autograft.[1] Over the past decade, quadriceps tendon autograft has increased in use, with data demonstrating comparable functional and patient-reported outcomes to other autograft options.[5-8]

From the Department of Orthopedic Surgery, Mayo Clinic Arizona, Phoenix, Arizona, U.S.A. (J.C.B., C.L., S.V.T., K.S.M., J.D.H., A.C.); Mayo Clinic Alix School of Medicine, Scottsdale, Arizona, U.S.A. (M.L.M., J.R.P.); and The Robert Larner M.D. College of Medicine at The University of Vermont, Burlington, Vermont, U.S.A. (A.B.T.).

Received July 2, 2023; accepted April 2, 2024.

Address correspondence to Joseph C. Brinkman, M.D., Mayo Clinic Arizona Department of Orthopedic Surgery, 5777 E. Mayo Blvd., Phoenix, AZ 85054, U.S.A. E-mail: Brinkman.Joseph@mayo.edu

2666-061X/23905

https://doi.org/10.1016/j.asmr.2024.100942

It is widely recognized that the Internet has enabled patients to readily access information about treatment choices and that patients are increasingly seeking this information online.[9] Although the choice of autograft is largely surgeon dependent, the increased use of quadriceps tendon autograft may reflect growing public awareness and subsequent requests for use of quadriceps tendon in ACL reconstruction. One way to evaluate trends in public interest is through analyzing aggregated Internet search data.[10,11] Within orthopaedic surgery, trend analyses have been performed to examine awareness of orthopaedic treatments and procedures, particularly those with mixed clinical results or controversial options.[12-14] One specific tool is Google Trends, which displays temporal relationships between search data generated within a specified time frame.

The purpose of this study was to use Google trends to explore differences in public interest among types of ACL autografts, specifically quadriceps tendon, patellar tendon, and hamstring tendon autografts, between 2008 and 2019. We hypothesized that, given the emerging data regarding quadriceps autograft, increasing interest in the quadriceps tendon autograft would be seen over the study time period.

Methods

Google Trends

Google Trends is a free, open-source data collection that reports online search volumes. These data are reported as a relative search volume (RSV), which is the search volume of a term compared with the peak popularity of a certain term during a defined time frame. After inputting a time frame of interest, the peak popularity of a term is assigned a value of 100. In addition, the Google Trends database reports an RSV stratified by time and geographic location.

Search Queries

Relative search volumes were created based on searches related to ACL reconstruction with comparative analysis generated for search terms related to quadriceps ACL, patellar tendon ACL, and hamstring ACL autografts. Search combinations used included "quad tendon ACL," "quadriceps tendon ACL," "ACL Quadriceps," and "ACL Quad" for quadriceps tendon autograft; "patellar tendon ACL" and "patellar ACL" for patellar tendon autograft; and "hamstrings ACL" and "hamstring tendon ACL" for hamstring tendon autograft.

Temporal Trends

Temporal trends in public interest for ACL reconstruction with quadriceps tendon autograft, hamstring tendon autograft, and patella tendon autograft were entered into the Google Trends tool. Only data from the US geographic region were utilized in this analysis. The resulting data for interest volume per term were compiled. The data were collected for a 12-year interval between January 1, 2008, and December 31, 2019, throughout the United States. The best-fit linear, quadratic, and exponential growth models were used to determine which model had the best fit. Best fit was determined by standard measures of accuracy, including mean absolute percentage error (MAPE), mean absolute deviation (MAD), and the mean squared deviation (MSD). To assess whether the public interest in the different methods of ACL reconstruction increased significantly over the 10-year time interval, a regression analysis was utilized for each technique.

Seasonal Trends

Seasonal trends were examined for ACL reconstruction between January 1, 2008, and December 31, 2019, by grouping the Google Trends data by month and season (spring = March through May, summer = June through August, fall = September through November, winter = December through February).

Statistical Analysis

Statistical analysis included linear regression analysis and comparison of cumulative annual search volumes for 2008 versus 2019. Microsoft Excel (Microsoft Corp) was used for statistical analysis.

Results

ACL Quadriceps Tendon Autograft

Between January 1, 2008, and December 31, 2019, Google Trends data demonstrated a statistically significant increase in RSV quadriceps tendon autograft for ACL reconstruction, with an R^2 value of 0.71 and $P < .001$. These data represented a linear increase in search volume, as a linear model was the most accurate line of best fit. The linear model had the following measures of accuracy: MAPE of 13.75, MAD of 4.25, and MSD of 25.23. The quadriceps autograft group demonstrated a 12-year search volume trend change of 0.56, which was significantly greater than the hamstring (0.07; $P < .001$) and patellar tendon (0.168; $P < .001$) groups. Percent change in average annual RSV between 2008 and 2019 was 112% for the quadriceps tendon group (Fig 1).

ACL Hamstring Tendon Autograft

Between January 1, 2008, and December 31, 2019, Google Trends data demonstrated no significant increase in RSV of ACL hamstring tendon autograft for ACL reconstruction, with an R^2 value of 0.05 and $P = .129$. These data represented a linear increase in search volume, as a linear model was the most accurate line of best fit. The linear model had the following

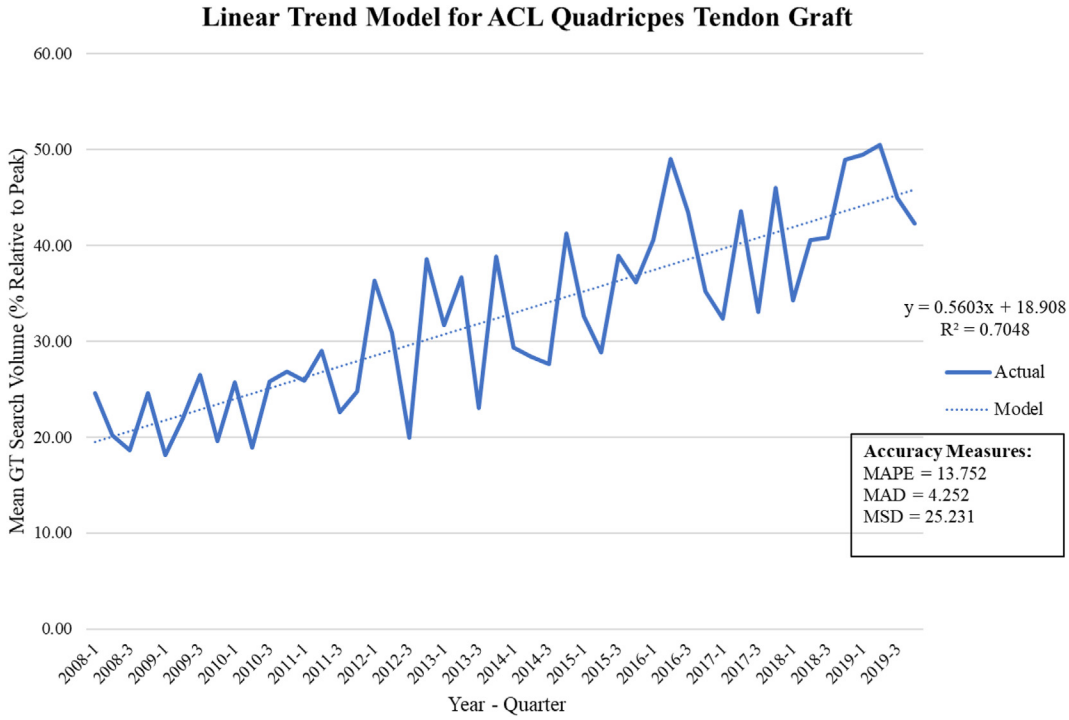

Fig 1. Linear trend model for anterior cruciate ligament quadriceps tendon autograft between January 1, 2008, and December 31, 2019.

measures of accuracy: MAPE of 6.94, MAD of 3.39, and MSD of 18.81. There was no significant difference in the trend change between hamstring and patellar tendon groups ($P = .20$). Percent change in cumulative relative annual search volumes between 2008 and 2019 was 12.9% for the hamstring group (Fig 2).

ACL Patella Tendon Autograft

Between January 1, 2008, and December 31, 2019, Google Trends data demonstrated a statistically significant increase in patellar tendon ACL autograft RSV, with an R^2 value of 0.15 and $P = .007$. These data represented a linear increase in search volume, as a linear model was the most accurate line of best fit. The linear model had the following measures of accuracy: MAPE of 10.15, MAD of 4.54, and MSD of 30.7. There was no significant difference in the trend change between hamstring and patellar tendon groups ($P = .020$). Percent change in cumulative relative annual search volumes between 2008 and 2019 was 18.6% for the patellar tendon group (Fig 3).

Seasonal Interest

The most interest was generated for quadriceps tendon ACL reconstruction and hamstring tendon ACL reconstruction during the fall season, with the least interest in the summer. The most interest for patella tendon autograft ACL reconstruction was during the spring season, with the least interest in the summer. Overall, there was more interest in hamstring tendon autograft in winter, spring, summer, and fall compared with quadriceps tendon autograft ACL reconstruction or patella tendon autograft ACL reconstruction (Fig 4).

Discussion

Our results demonstrated a significantly higher volume trend of searches related to quadriceps tendon autograft rather than patellar or hamstring autografts in ACL reconstruction. Additionally, averaged yearly RSV between 2008 and 2019 for quadriceps autograft increased 112% over the studied period, while less change was noted in cumulative search volumes for the hamstring (12.9%) and patellar tendon (18.6%) groups.

The Internet has become an increasingly relied upon resource for individuals' information needs.[15] In health care, this has resulted in a significant increase in information-seeking behavior by patients.[9] Studies of this phenomenon in orthopaedics have revealed that patients are searching for information related to certain treatments such as platelet-rich plasma and stem cell injections at an increasing rate.[12,13] Our study adds to the limited body of literature on information-seeking behavior related to ACL reconstruction or different autograft options in orthopaedics. We report an increasing rate of searches related to quadriceps tendon autografting in ACL reconstruction, which reflects findings of previous reports regarding increased online searches for new or

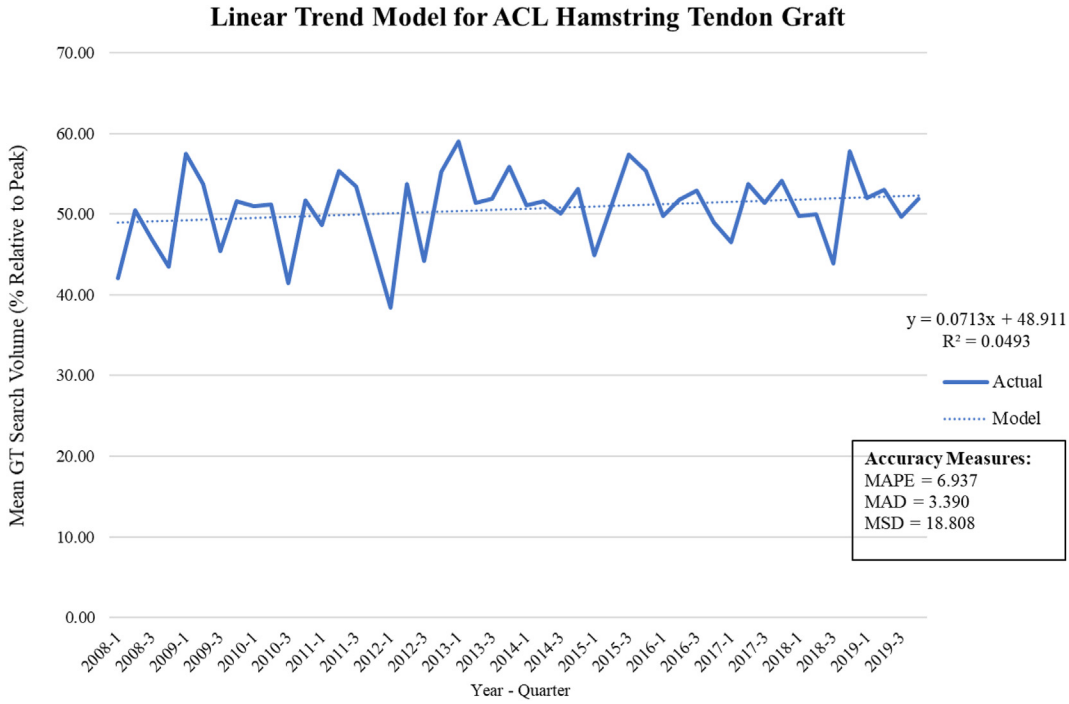

Fig 2. Linear trend model for anterior cruciate ligament hamstring tendon autograft between January 1, 2008, and December 31, 2019.

emerging treatments in orthopaedics. However, trends regarding hamstrings and patellar tendon autografting over the studied 12 years were relatively static. Together, our results suggest that individuals are most interested in learning about quadriceps tendon autografting in ACL reconstruction.

Increasing patient interest in quadriceps autograft ACL reconstruction is not supported by current evidence.

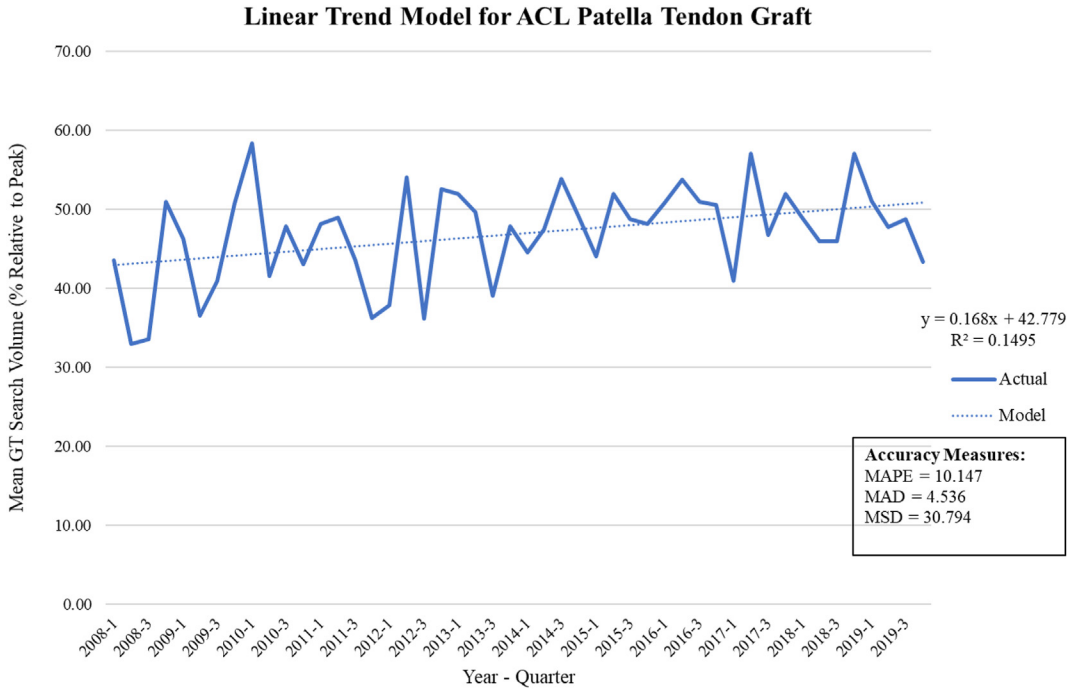

Fig 3. Linear trend model for anterior cruciate ligament patella tendon autograft between January 1, 2008, and December 31, 2019.

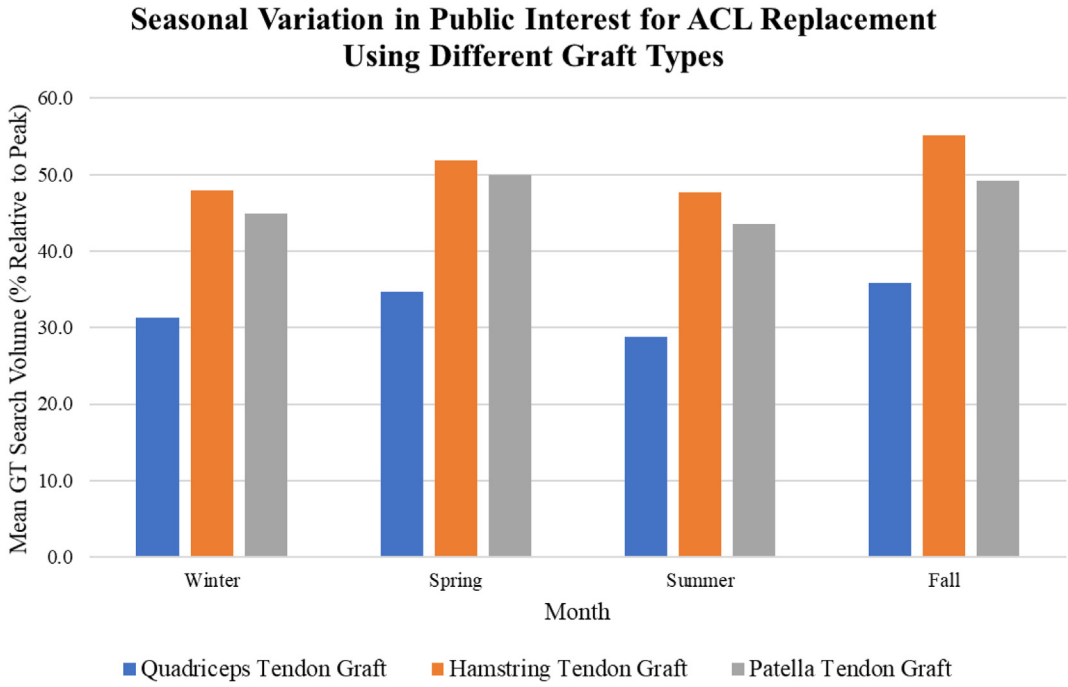

Fig 4. Seasonal variation in public interest for anterior cruciate ligament replacement using different autograft types between January 1, 2008, and December 31, 2019.

Further study is needed to determine the long-term outcomes, complications, and survivability of quadriceps tendon autograft use in ACL reconstruction. The reasons for increasing public interest in quadriceps tendon autograft for ACL reconstruction is therefore difficult to assess and likely multifactorial. One contributing factor is likely due to recent studies that have demonstrated that patients are particularly interested in researching emerging technologies online, which can lead to unrealistic patient expectations.[16] For example, unrealistic patient expectations in orthopaedics have been noted in total joint arthroplasty, as patients tend to have an exaggerated understanding of the benefits versus risks of robotic over conventional arthroplasty.[17] As clinical outcomes do not support this notion, authors suggest that powerful marketing campaigns are responsible for this misinformation. Although studies comparing differential marketing campaigns for ACL autografts are lacking, many surgeon and hospital websites explain the benefits of quadriceps tendon (QT) over other autografts and why patients should consider it as the ideal autograft option.[18-20] Marketing efforts such as these may contribute toward the findings reported in this study. Additionally, formal reports have touted the QT as the "autograft of the future."[21] This idea likely further contributes to increased interest in QT autograft on behalf of patients and families. Although public websites and formal studies report the promise of the QT autograft, further long-term studies are needed to objectively justify and appropriately guide public interest in the area.

Our results also allowed for analysis of seasonal variation in public interest in the different autograft options. Fall appeared as the season with most interest regarding autograft ACL reconstruction. This coincides with a separate study on public interest in platelet-rich plasma therapy for hip and knee osteoarthritis, which was shown to peak in October.[12] It is difficult to interpret this given the scope of the current study. However, these results are consistent with epidemiologic studies of soccer athletes that report a peak incidence of ACL injuries during the beginning of the season (September-October).[22,23] Further, a higher interest in ACL reconstruction during late fall may root from an interest to seek surgery prior to health care deductible resetting at the beginning of the new year or increased injury during the football season.

Limitations

The presented study has several limitations. Google Trends is limited in scope despite providing national search volume data. It does not capture demographics, detailed geographic location, specific search terms, or absolute search volume numbers. As a result, subsequent analyses are inherently limited in granularity. It is also possible that certain populations search more frequently than others, and thus online search volumes may represent a subset of the population. Additionally, Google trends does not afford analyses of searches performed using other online search engines. The analysis and interpretation provided in this study depend on a close relationship between online search

volumes and actual patient or physician interest. It remains unclear how closely these 2 factors correlate, but our study and similar previous studies propose that they are a reliable proxy to measure patient interest.

Conclusions

This study indicates a consistently increasing public interest in quadriceps tendon autograft for ACL reconstruction. The quadriceps autograft group demonstrated a significantly greater 12-year online search volume, greater linear correlation, and larger percent change between 2008 and 2019 compared with patellar tendon or hamstring autograft groups.

Disclosures

The authors report no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

References

1. Chambat P, Guier C, Sonnery-Cottet B, Fayard JM, Thaunat M. The evolution of ACL reconstruction over the last fifty years. *Int Orthop* 2013;37:181-186.
2. Kaeding CC, Léger-St-Jean B, Magnussen RA. Epidemiology and diagnosis of anterior cruciate ligament injuries. *Clin Sports Med* 2017;36:1-8.
3. DeFazio MW, Curry EJ, Gustin MJ, et al. Return to sport after ACL reconstruction with a BTB versus hamstring tendon autograft: A systematic review and meta-analysis. *Orthop J Sports Med* 2020;8:2325967120964919.
4. Yang XG, Wang F, He X, et al. Network meta-analysis of knee outcomes following anterior cruciate ligament reconstruction with various types of tendon grafts. *Int Orthop* 2020;44:365-380.
5. DeAngelis JP, Fulkerson JP. Quadriceps tendon—a reliable alternative for reconstruction of the anterior cruciate ligament. *Clin Sports Med* 2007;26:587-596.
6. Fulkerson JP, Langeland R. An alternative cruciate reconstruction graft: The central quadriceps tendon. *Arthroscopy* 1995;11:252-254.
7. Roe J, Pinczewski LA, Russell VJ, Salmon LJ, Kawamata T, Chew M. A 7-year follow-up of patellar tendon and hamstring tendon grafts for arthroscopic anterior cruciate ligament reconstruction: Differences and similarities. *Am J Sports Med* 2005;33:1337-1345.
8. 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;31:541-554.
9. Pesälä S, Virtanen MJ, Sane J, Mustonen P, Kaila M, Helve O. Health information-seeking patterns of the general public and indications for disease surveillance: Register-based study using Lyme disease. *JMIR Public Health Surveill* 2017;3:e86.
10. Duggan RP, Tran JP, Phillips LG. Interest in plastic surgery during COVID-19 pandemic: A Google Trends analysis. *Plast Reconstr Surg Glob Open* 2020;8:e3268.
11. Walker A, Hopkins C, Surda P. Use of Google Trends to investigate loss-of-smell-related searches during the COVID-19 outbreak. *Int Forum Allergy Rhinol* 2020;10:839-847.
12. Cohen SA, Zhuang T, Xiao M, Michaud JB, Amanatullah DF, Kamal RN. Google Trends analysis shows increasing public interest in platelet-rich plasma injections for hip and knee osteoarthritis. *J Arthroplasty* 2021;36:3616-3622.
13. Strotman PK, Novicoff WM, Nelson SJ, Browne JA. Increasing public interest in stem cell injections for osteoarthritis of the hip and knee: A Google Trends analysis. *J Arthroplasty* 2019;34:1053-1057.
14. Tijerina JD, Cohen SA, Parham MJ, et al. Public interest in elective orthopedic surgery following recommendations during COVID-19: A Google Trends analysis. *Cureus* 2020;12:e12123.
15. Marton C, Choo CW. A review of theoretical models of health information seeking on the web. *J Documentation* 2012;68:330-352.
16. Caulfield T, Condit C. Science and the sources of hype. *Public Health Genomics* 2012;15:209-217.
17. Pagani NR, Moverman MA, Puzzitiello RN, Menendez ME, Barnes CL, Kavolus JJ. Online crowdsourcing to explore public perceptions of robotic-assisted orthopedic surgery. *J Arthroplasty* 2021;36:1887-1894.e3.
18. ACL Doctor. Best ACL graft for a professional athlete | best ACL reconstruction surgeon. July 16, 2020. https://theacldoctor.com/best-acl-graft-for-a-professional-athlete/. Accessed December 13, 2021.
19. Children's Hospital Colorado. Best way to reconstruct ACL. https://www.childrenscolorado.org/conditions-and-advice/sports-articles/sports-injuries/acl-graft-options/. Accessed December 13, 2021.
20. Sterett B. Female athletes should consider a quad tendon ACL graft. https://drsterett.com/sports-medicine-blog/acl-quad-tendon-graft. Accessed December 13, 2021.
21. Xerogeanes JW. Quadriceps tendon graft for anterior cruciate ligament reconstruction: The graft of the future! *Arthroscopy* 2019;35:696-697.
22. Grassi A, Macchiarola L, Filippini M, Lucidi GA, Della Villa F, Zaffagnini S. Epidemiology of anterior cruciate ligament injury in Italian First Division soccer players. *Sports Health* 2020;12:279-288.
23. Villa FD, Buckthorpe M, Grassi A, et al. Systematic video analysis of ACL injuries in professional male football (soccer): Injury mechanisms, situational patterns and biomechanics study on 134 consecutive cases. *Br J Sports Med* 2020;54:1423-1432.