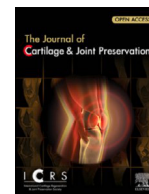




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Original Research

Clicks and cartilage: tracking virtual patient interest in cartilage repair procedures

Irfan A. Khan^a, Thomas E. Moran^b, Krish S. Sardesai^c, Katie Kessler^b, Jared Sachs^c, Dillon Synchef^c and Brian J. Cole^{c,*}^a LSU Health New Orleans, Department of Orthopaedic Surgery, New Orleans, LA, United States^b Medical University of South Carolina, Department of Orthopaedic Surgery, Charleston, SC, United States^c Midwest Orthopaedics at Rush University Medical Center, Chicago, IL, United States

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ABSTRACT

Introduction: Osteochondral allograft (OCA) and matrix-induced autologous chondrocyte implantation (MACI) procedures show increasing incidence, while microfracture and osteochondral autograft transfer system (OATS) show decreasing incidence. Whether public interest correlates with procedure volumes remains unclear. There is a paucity of studies evaluating readability of patient education articles on cartilage repair.

Objectives: The objective was to evaluate public interest in cartilage restoration using Google Trends and assess readability of patient education articles. We hypothesized public interest would parallel performance trends and readability would be poor.

Methods: Google Trends was queried for cartilage repair procedures between January 2017 and December 2024. Mean relative search volume (RSV) was obtained for "cartilage repair" and microfracture, OATS, OCA, and MACI [RSV ranges 0-100]. Readability of the first 25 articles from "cartilage repair surgery" search was assessed using Flesch-Kincaid Reading Level (FKGL) and Flesch Reading Ease Score. Statistical analysis included variance tests with significance at $P < .05$. **Results:** Mean RSV for "cartilage repair" increased significantly (+17; $P < .001$). Microfracture had the highest mean RSV (68; $P < .001$). Despite being most searched, microfracture's RSV decreased significantly (-27; $P < .001$), as did OATS (-14; $P < .001$). Conversely, RSV increased significantly for OCA (+17; $P < .001$) and MACI (+73; $P < .001$). Mean FKGL was 10.9 and Flesch Reading Ease Score was 43.6, with no articles at American Medical Association (AMA)-recommended sixth grade level.

Conclusions: Public interest in cartilage repair is increasing, with OCA and MACI showing increasing interest and microfracture and OATS showing decreasing interest, correlating with published procedure volume trends. Patient education articles exceed AMA-recommended reading levels.

* Brian J. Cole, Midwest Orthopaedics at Rush University Medical Center, 1611 W Harrison Street, Chicago, IL 60612.

Email address: brian.cole@rushortho.com (B.J. Cole).

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Introduction

Epidemiologic studies have demonstrated a high prevalence of cartilage lesions in young, healthy athletes, with rates ranging from 36% to 72% in soccer players, 41% to 50% in basketball players, and similarly elevated rates across other sports.¹ While initial nonsurgical treatment is favored, several modalities for cartilage restoration exist as well-validated surgical treatments for focal and symptomatic articular cartilage lesions that are recalcitrant to conservative management.² Options, including microfracture, osteochondral allograft transplantation (OCA), autologous chondrocyte implantation, and osteochondral autograft transfer system (OATS), have been employed to provide patients with pain relief and to improve function.² Patients increasingly utilize online resources to explore treatment options, often using search engines and video platforms to inform their decision-making.³ Yet, the quality and consistency of online content remain highly variable, with prior studies showing that publicly available information is frequently incomplete or inconsistent with best clinical practices.^{3,4} Despite this, large-scale surveys confirm that patients often act on the information they find online, including changing health behaviors, initiating physician conversations, and scheduling appointments based on content consumption.⁵

Given this level of engagement, it is increasingly important to understand how online resources influence treatment decisions, and, thus, trends in treatment utilization. Tools such as Google Trends (Alphabet Inc) offer a scalable means to quantify shifts in online search behavior over time.⁶ It has been increasingly utilized in medical research to assess population-level interest, monitor health-related behaviors, and identify emerging trends.^{7–9} Prior work in orthopedics has demonstrated that Google Trends can detect changes in public engagement and variation in procedural interest.^{8,10–12} Notably, one study found a significant correlation between search volume and national case volume for total knee and hip arthroplasty, suggesting that online search behavior may reflect procedural demand, yet search behavior related to cartilage restoration remains underexplored.¹¹ Given the increasing utilization of cartilage restoration procedures and the variability in online information quality, evaluating public search behavior may offer valuable insight into how these interventions are perceived outside of clinical settings. There is also significant value in quantifying the complexity of the online resources that patients' Internet searches yield. The American Medical Association (AMA) has set a goal that online educational material should not exceed a sixth-grade reading level, though there is a paucity of literature assessing the readability of online material pertaining to cartilage restoration surgery.¹³

In sum, the primary objective of the current study was to assess public interest in cartilage restoration procedures using Google Trends over 8 years (2017–2024) to (1) evaluate temporal trends in search volume and determine potential relationships between online interest and chosen surgical techniques; and (2) to assess the readability associated with patient-targeted cartilage restoration articles. We hypothesized that (1) trends in public interest in cartilage restoration procedures would positively correlate with trends in utilization of the respective procedures; and (2) that the readability of articles on cartilage restoration procedures would be poor, leading to further inquiries on patient education and surgical preference.

Materials and methods

Study design and setting

A retrospective longitudinal study was performed utilizing Google Trends from January 2017 to December 2024 evaluating public interest in cartilage repair procedures in the United States. Included were the 4 most common cartilage repair procedures which are currently available and clinically utilized in the United States: microfracture, osteochondral allograft transfer system (OATS), OCA, and matrix-induced autologous chondrocyte implantation (MACI). January 2017 was specifically selected due to MACI being approved for utilization by the FDA in December 2016.¹⁴ When determining whether to include “MACI” or “autologous chondrocyte implantation” in the study analysis above, the mean RSV for “MACI” versus “autologous chondrocyte implantation” was compared, revealing greater public utilization of the term “MACI” in Google searches (10 vs 2; $P < .001$). Due to this, “MACI” was used to represent autologous chondrocyte implantation. For surgical techniques like OATS and OCA, which have existed and been reported for much longer than MACI, similar comparison was conducted to assess which string value was most popularly utilized. This process is to ensure our analysis best represents public interest rather than semantic variation. For OATS, “OATS procedure” was utilized and for OCA, “osteochondral allograft” was utilized. Through the Google Trends software, the mean relative search volume (RSV) was obtained for “cartilage repair” (Table 1), and each of the 4 most common cartilage repair procedures as a string value (eg, “microfracture,” “OATS procedure,” “osteochondral allograft,” “MACI procedure”) (Table 2). RSV is provided as a numerical value from 0 to 100, with 0 representing no public interest in a search term and 100 representing maximum public interest in a search term.

Table 1

Search syntax utilized in Google Trends software for different ways of saying cartilage repair procedures.

Search terms input into Google Trends software
“Cartilage Repair”
“Cartilage Regeneration”
“Cartilage Reconstruction”
“Cartilage Restoration”
“Cartilage Transplantation”

Table 2

Search syntax utilized in Google Trends software for specific cartilage repair procedures.

Search terms input into Google Trends software
“Microfracture”
“OATS Procedure”
“Osteochondral Allograft”
“MACI Procedure”
“Autologous Chondrocyte Implantation”

Additionally, the mean RSV for “cartilage repair” and the 4 most common cartilage repair procedures (microfracture, OATS, OCA, and MACI) was obtained and compared every year from January 2017 to December 2024 to evaluate how public interest for each search term has trended over time.

To obtain the reading level for online patient education articles regarding cartilage repair procedures, a Google search consisting of “cartilage repair procedures” was performed in incognito mode on May 19, 2025. Through using the guidelines recommended by Badarudeen et al, the Flesch-Kincaid Reading Level and Flesch Reading Ease Score were obtained for the first 25 text-based articles that appeared in the Google search.¹⁵ The text for each article was inputted into Microsoft Word (Microsoft Corporation), and the Flesch Reading Ease Score and Flesch-Kincaid Reading Level were obtained. The proportion of articles meeting the AMA recommended reading level of sixth grade was determined.¹³ Articles included in this study were classified as being published by one of 3 various sources: nonprofit organizations, academic institutions, and private-practice institutions. Additionally, the specific number of cartilage repair procedures and specific procedure included in each article was obtained for analysis to determine how many procedures on average articles are discussing, and to determine which procedures are most commonly discussed.

Inclusion and exclusion criteria

Inclusion criteria for this study comprised search terms in Google Trends having an available mean RSV between January 2017 and December 2024. Exclusion criteria for this study for the Google Trends portion of the study comprised search terms with no mean RSV in Google Trends available between January 2017 and December 2024, with no search term meeting this criteria, and exclusion criteria for the article readability portion of this study included articles in Google which had only embedded videos for patient education with no readable text (1 video-based article was excluded), which would not allow for text to be inputted into Microsoft Word to obtain a Flesch-Kincaid Reading Level or Flesch Reading Ease Score, and published peer-reviewed research articles, which are not intended for patients to read to obtain information about surgical procedures (2 published articles were excluded).

Study outcomes

The primary outcome for this study comprised evaluating the mean RSV for “cartilage repair” over time and determining whether it was trending upward, plateaued, or trending downwards. Secondary outcomes for this study comprised comparing the mean RSV for the 4 most common cartilage repair procedures (microfracture, OATS, OCA, and MACI), and evaluating the readability of the first 25 patient education articles for “cartilage repair surgery” in a Google search through obtaining the mean Flesch-Kincaid Reading Level for each article.

Statistical analysis

When analyzing continuous data, Student *t* tests or analysis of variance (ANOVA) tests were utilized. When presenting continuous data throughout the manuscript, it was presented as mean (standard deviation [SD]). When analyzing categorical data, χ^2 tests were utilized. When presenting categorical data, it was presented as count (percentage). When evaluating whether a significant difference in mean RSV exists over time for a specific search term, the Pearson correlation coefficient was utilized. A Pearson correlation coefficient of 0.90 or higher represented a very strong correlation, a correlation coefficient of 0.70-0.89 represented a strong correlation, and so on.¹⁶ Statistical significance was defined at a *P*-value less than .05. All analyses were conducted utilizing Microsoft Excel (Version 16.72) Data Analysis Package.

Results

Between 2017 and 2024, amongst the 5 search terms “cartilage repair,” “cartilage regeneration,” “cartilage reconstruction,” “cartilage restoration,” and “cartilage transplantation,” “cartilage repair” had the highest mean RSV (60.4 vs 16.1 vs 2.9 vs 2.7 vs 0.1; *P* < .001). Between 2017 and 2024, the mean RSV for “cartilage repair” increased significantly over time (2017: 57; 2024: 74; *P* < .001) (Fig. 1), with the correlation coefficient over time being 0.776 (*P* = .024).

Between 2017 and 2024, amongst 4 common cartilage repair procedures (microfracture, OATS, OCA, and MACI), microfracture was the most commonly searched procedure with the highest mean RSV (68.3 vs 18.5 vs 13.6 vs 10.0; *P* < .001) (Fig. 2).

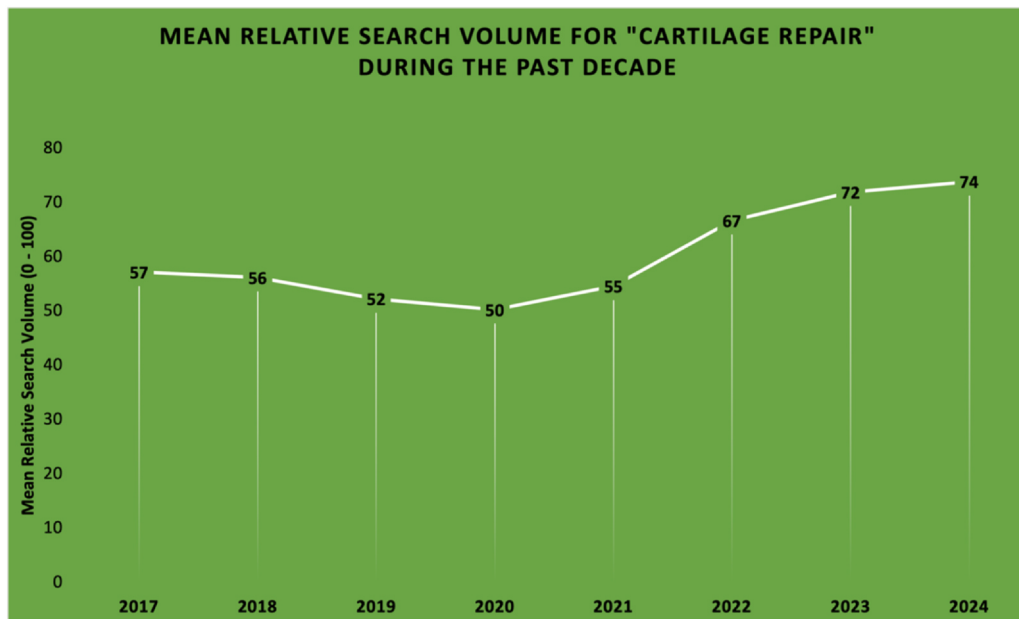


Fig. 1. Mean relative search volume for cartilage repair from 2017-2024, displaying an increase over the study period.

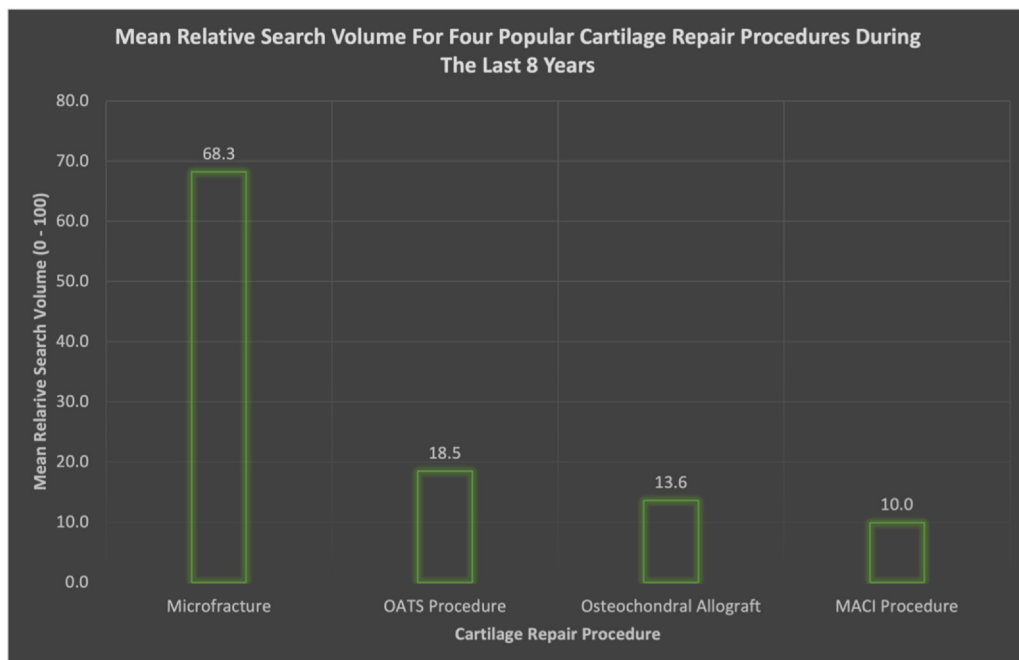


Fig. 2. Mean relative search volume for popular cartilage repair procedures between 2017-2024, displaying that microfracture exhibited the greatest public interest over the study period. MACI, matrix-induced autologous chondrocyte implantation; OATS, osteochondral autograft transfer system.

Despite “microfracture” being the most commonly searched procedure, its mean RSV decreased significantly over time (2017: 90; 2024: 63; $P < .001$) (Fig. 3), with a correlation coefficient over time being -0.812 ($P = .013$). Additionally, the mean RSV for “OATS procedure” decreased significantly during the last decade (2017: 75; 2024: 61; $P < .001$) (Fig. 4), with a correlation coefficient over time being -0.704 ($P = .050$).

In contrast, the mean RSV for “osteochondral allograft” has significantly increased during the last decade (2017: 51; 2024: 68; $P < .001$) (Fig. 5), with a correlation coefficient over time being 0.711 ($P = .048$). Additionally, the mean RSV for “MACI procedure”

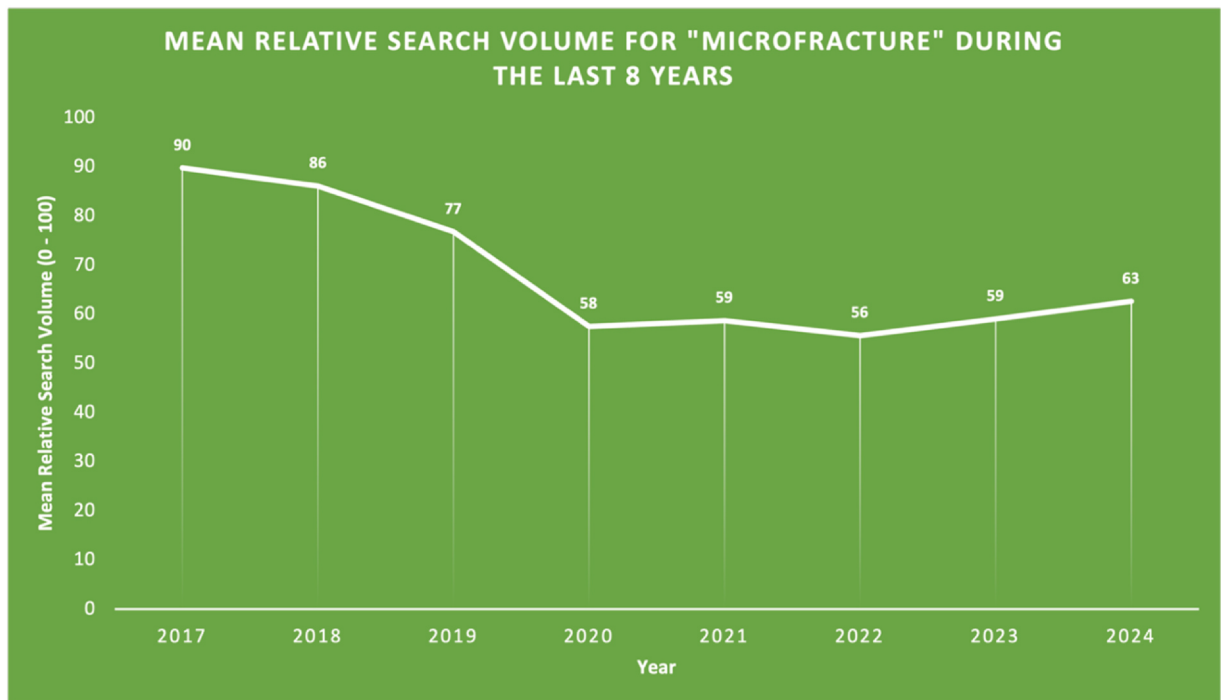


Fig. 3. Mean relative search volume for microfracture from 2017-2024, which shows a significant decrease over the study period.

has also significantly increased during the last decade (2017: 5; 2024: 78; $P < .001$) (Fig. 6), with a correlation coefficient over time being 0.993 ($P < .001$).

When assessing the readability of the first 25 articles that appeared on a Google search of “cartilage repair procedures,” the mean Flesch Reading Ease was 43.6, while the mean Flesch-Kincaid Reading Grade Level (FKGL) was 10.9. Amongst 25 articles included in the analysis, no articles were at or below the AMA recommended sixth grade reading level (0/25, 0%) (Fig. 7).

When analyzing the 25 articles included in the readability analysis, 11 articles were written by academic institutions, 13 articles were written by private practices, and 1 article was written by a nonprofit organization. The mean number of procedures that were discussed in each article was 5 procedures (range 2-7). When analyzing the most popular procedures covered in articles about cartilage repair procedures, microfracture was included in 25/25 (100%) of articles, MACI and OATS were included in 23/25 (92%) of articles, OCA was included in 19/25 (76%) of articles, and abrasion chondroplasty was included in 17/25 (68%) of articles.

Discussion

The primary objective of the current study was to evaluate public interest in cartilage restoration procedures using Google Trends and to assess the readability of patient education articles on cartilage repair procedures. The most significant findings of the current study were that public search interest in cartilage repair increased significantly over 10 years. Furthermore, OCA and MACI procedures demonstrated increasing interest over time, and microfracture and OATS procedures demonstrated decreasing interest over time. Finally, easily accessible cartilage repair articles demonstrated a mean FKGL of 10.9 and Flesch Reading Ease score of 43.6.

During the study period, the search term “cartilage repair” exhibited the greatest RSV, which increased by nearly 20% during the period of interest. This finding bears relevance as patients are increasingly utilizing online search engines and reference sources for self-education regarding conditions and treatment options. Fraval et al suggest that approximately 65% of orthopedic outpatients utilize the internet for information regarding their condition, and over half of this cohort use the internet to research their surgeon.¹⁷ Furthermore, this reliance on internet resources may be more prevalent in orthopedic sports medicine in comparison to other orthopedic subspecialties.¹⁸ Understanding existing trends and ensuring access to appropriate resources is important, as knowledge gained from online searches may directly influence patient-physician interactions and treatment expectations. Previous literature has identified that nearly one in 3 patients asks their surgeons questions stemming from their independent online research.¹⁷ Identification of existing trends provides an understanding of public interest surrounding this topic and may inform biases in patient perception, as patients not only consult the internet more for clinical information, but are also more likely to deem the information they read as accurate.¹⁹

When stratifying further by respective cartilage repair or restoration procedures, microfracture and OATS exhibited the highest mean RSV (68 vs 19), although both displayed a decrease in RSV over the study period (by 30% and 20%, respectively). Declining public interest in microfracture appears to align with a decreasing frequency of relative caseload, as more than half of surgeons report

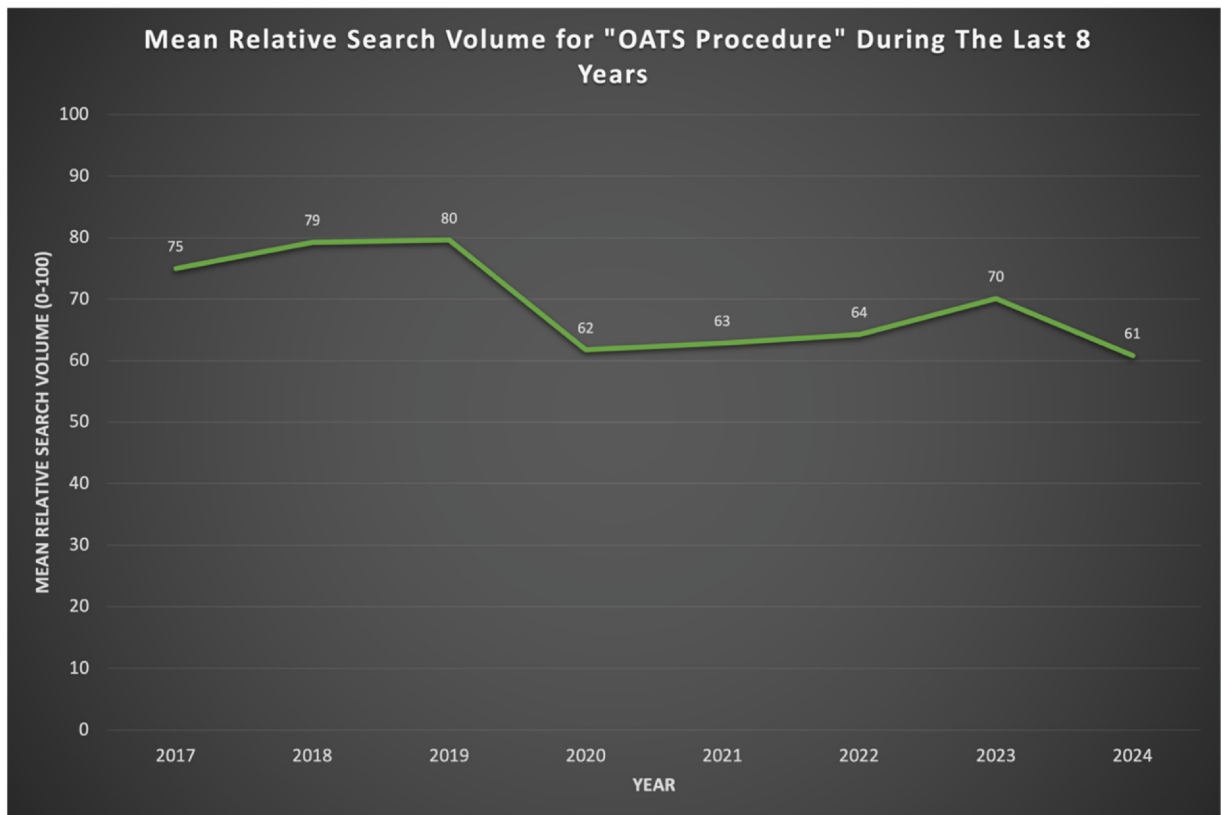


Fig. 4. Mean relative search volume for OATS procedure from 2017-2024, which shows a significant decrease over the study period. OATS, osteochondral autograft transfer system.

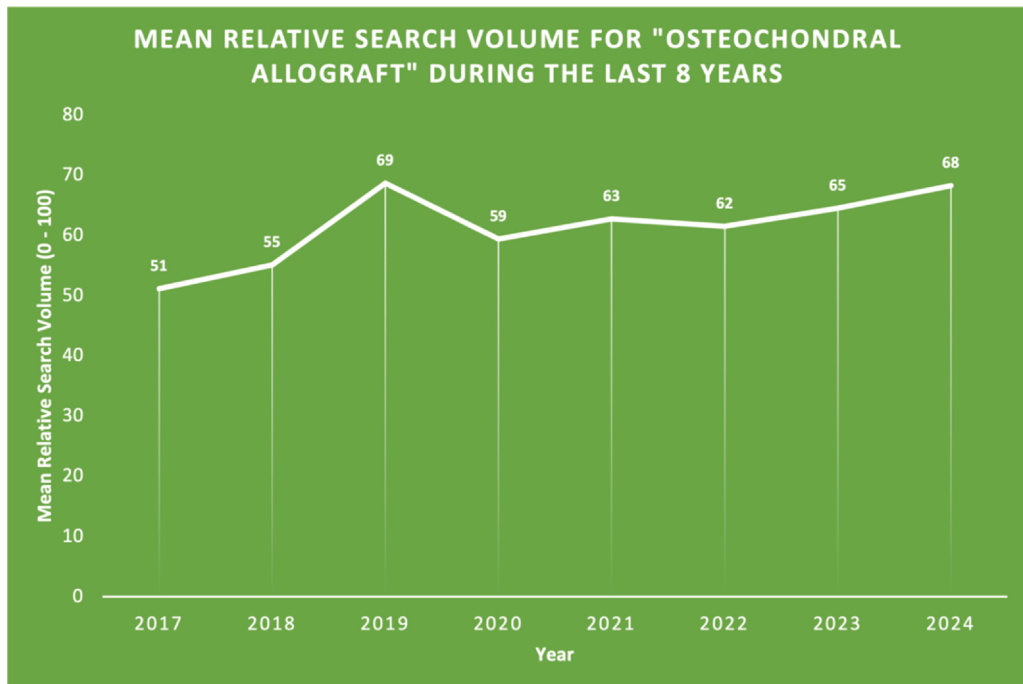


Fig. 5. Mean relative search volume for osteochondral allograft from 2017-2024, which shows a significant increase over the study period.

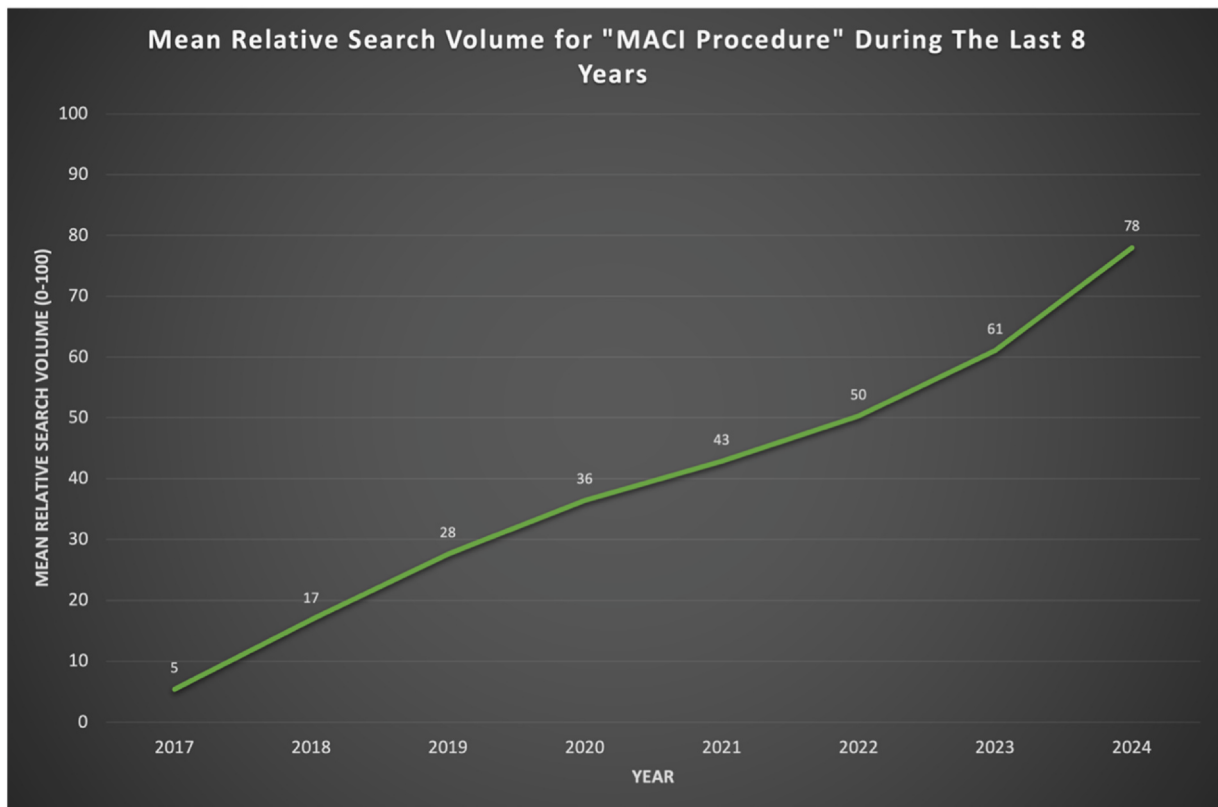


Fig. 6. Mean relative search volume for MACI procedure during 2017-2024, which shows a significant increase over the study period. MACI, matrix-induced autologous chondrocyte implantation.

performing the procedure less frequently in 2020 compared to 5 years prior.²⁰ Compared to microfracture and OATS, OCA and MACI exhibited lower mean RSV (14 vs 10), but the latter 2 exhibited increases in RSV over the study period. Similarly, increased public interest in OCA appears to mirror a substantial increase in these procedures' popularity since 2011. These trends also are supported by emerging evidence regarding good to excellent long-term survivorship after OCA and MACI.^{21,22} Ultimately, congruence between Google Search trends and relative caseload trends suggest that public search behavior may be representative in monitoring health care demand surrounding cartilage repair or restoration.

Finally, the current analysis regarding Google search trends and results demonstrated that cartilage repair or restoration articles easily accessible via Google largely do not meet the AMA-recommended sixth-grade reading level. The mean FKGL was 10.9, while the mean Flesch Reading Ease score was 43.6. The FKGL metric utilizes the number of sentences, words, and syllables to calculate a reading level, using US grade school levels as reference.²³ In sum, as patients increasingly utilize Google for information around cartilage restoration procedures, the resources found contain information written at the level of a near high-school graduate, exceeding what is intended by the AMA. The Flesch Reading Ease score relies on the average number of words per sentence and syllables per word, with a higher score (0-100) conferring text that is easier to read. A Flesch Reading Ease score of 90 to 100 indicates clear text, at the level of conversational English, while a score of 60 to 70 indicates an eighth to ninth-grade reading level.^{15,24} The current analysis demonstrated a mean Flesch Reading Ease of 43.6, indicating a disparity between the sample and the AMA goal. This difference may lead to impairment in the understanding of treatment risks, benefits, and expectations, particularly in patients with lower health literacy.

Limitations

There are several limitations to the current study. Google is only one online search engine that may be utilized by patients, and as a result, RSV may not be an all-encompassing metric for public sentiment. Many patients also utilize websites belonging to their surgeons, physical handouts, word-of-mouth, and increasingly, artificial intelligence-based resources. However, Google serves as a consistent, quantifiable metric that allows for objective measurement of trends in interest on a subject over time. Additionally, our assessment of Google Trends and readability metrics was limited to the English language. Patients may utilize resources in other languages, and therefore, our analysis may not comprehensively describe a multicultural orthopedic surgery patient population. Though we included 4 cartilage restoration procedures, there are emerging "new generation" treatment modalities (eg, aragonite

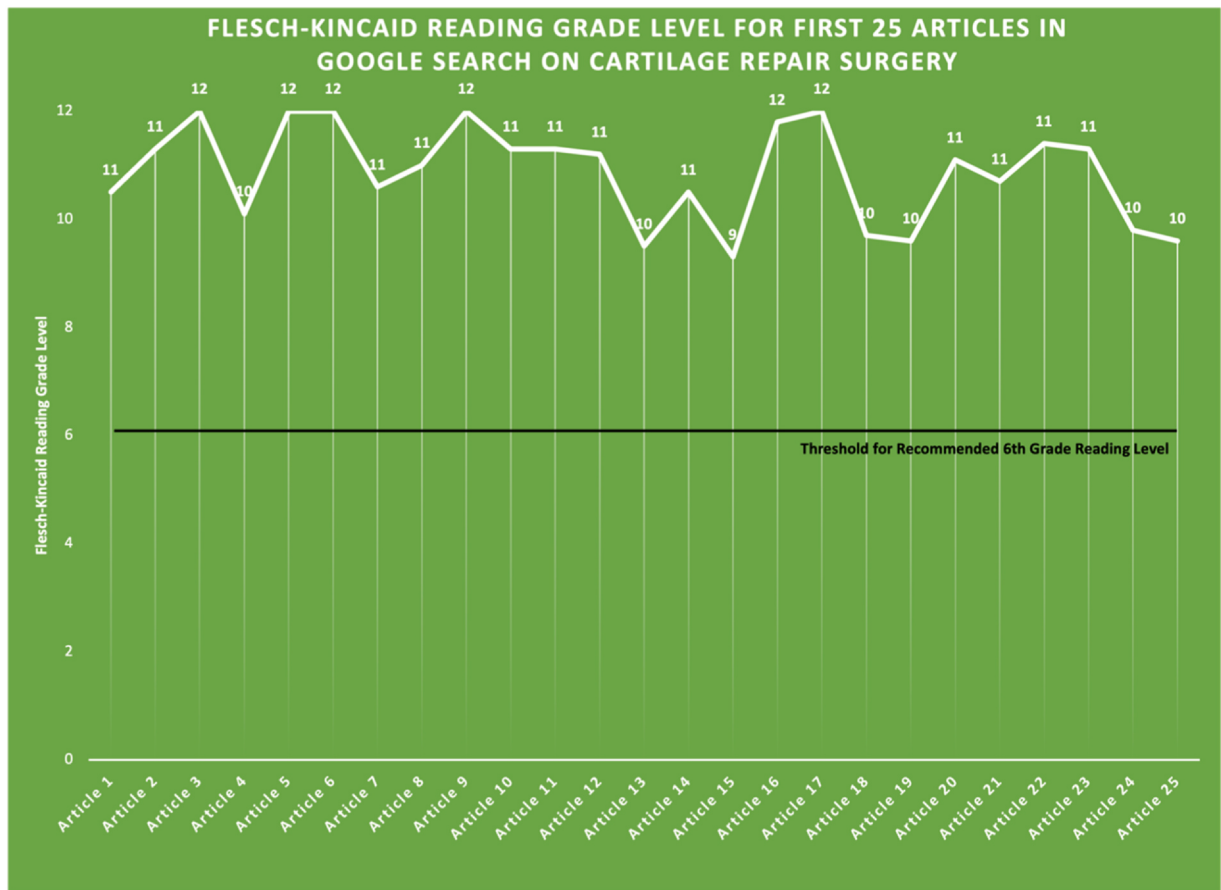


Fig. 7. Flesch-Kincaid Reading Grade Level for 25 articles in Google Search on cartilage repair surgery, which exceeds the recommended reading grade level.

biocompatible implants) which were not included due to their relative recency. Our current methodology would, therefore, be inappropriate to gauge decade-long interest in such innovative technology. Future studies ought to consider how trends in these “new generation” technologies mimics clinical use in their first decade of utilization, after clearance and widespread adoption. Finally, there is inherent sampling bias in selecting specific search terms—specifically 4 cartilage restoration procedures—and 25 patient education websites, which may not be entirely representative of online resources and utilization. Still, these data serve as an important snapshot of the state of online education in cartilage restoration and how it has evolved over the past 10 years. Future studies should investigate the variable utilization of online education over various media, languages, and with regard to other orthopedic sports medicine procedures.

Conclusion

Public interest in cartilage repair procedures has increased between 2017 and 2024. Online search interest correlates with published trends in the volume of respective cartilage repair procedures being performed. Additionally, patient education articles discussing cartilage repair procedures are written at levels of education exceeding those recommended by the AMA.

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Ethics approval

The authors declare that informed patient consent was not provided for the following reason: This study does not involve patient data in any capacity and thus is exempt from IRB review and any other patient consent procedure.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Corresponding Author - Aesculap/B.Braun: Research support (BJC), Medipost Inc: Research Support (BJC) American Journal of Sports Medicine: Editorial or governing board (BJC), Arthrex Inc: IP royalties, paid consultant, research support (BJC), Moximed: Financial Interests, Bandgrip Inc: Stock or stock options (BJC), Elsevier Publishing: IP royalties, publishing royalties, financial or material support (BJC), Journal of the American Academy of Orthopedic Surgeons: Editorial or governing board (BJC), JRF Ortho: Other financial or material support (BJC), National Institutes of Health (NIAMS & NICHD): Research support (BJC), Ossio: Stock or stock options (BJC). 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.

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