Original Article

Indications for Surgery, Activities After Surgery, and Pain Are the Most Commonly Asked Questions in Anterior Cruciate Ligament Injury and Reconstruction

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Purpose: To leverage Google's search algorithms to summarize the most commonly asked questions regarding anterior cruciate ligament (ACL) injuries and surgery. **Methods:** Six terms related to ACL tear and/or surgery were searched on a clean-installed Google Chrome browser. The list of questions and their associated websites on the Google search page were extracted after multiple search iterations performed in January of 2022. Questions and websites were categorized according to Rothwell's criteria. *The Journal of the American Medical Association* (JAMA) Benchmark criteria were used to grade website quality and transparency. Descriptive statistics were provided. χ^2 and Student *t*-tests identified for categorical differences and differences in JAMA score, respectively (significance set at $P < .05$). **Results:** A total of 273 unique questions associated with 204 websites were identified. The most frequently asked questions involved Indications/Management (20.2%), Specific Activities (15.8%), and Pain (10.3%). The most common websites were Medical Practice (27.9%), Academic (23.5%), and Commercial (19.5%). In Academic websites, questions regarding Specific Activities were seldom included (4.7%) whereas questions regarding Pain were frequently addressed (39.3%, $P = .027$). Although average JAMA score was relatively high for Academic websites, the average combined score for medical and governmental websites was lower ($P < .001$) than nonmedical websites. **Conclusions:** The most searched questions on Google regarding ACL tears or surgery related to indications for surgery, pain, and activities postoperatively. Health information resources stemmed from Medical Practice (27.9%) followed by Academic (23.5%) and Commercial (19.5%) websites. Medical websites had lower JAMA quality scores compared with nonmedical websites. **Clinical Relevance:** These findings presented may assist physicians in addressing the most frequently searched questions while also guiding their patients to greater-quality resources regarding ACL injuries and surgery.

Anterior cruciate ligament (ACL) tears are among the most common sports-related injuries,[1] with an increasing incidence of reconstructions performed annually in the United States.[2,3] Patients considering this elective surgery often search the internet regarding their condition before and after clinical appointments. Previous literature has highlighted that many patients discuss the results of their initial search with their

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surgeons.[4-10] In a systematic review of online information available to patients for orthopaedic surgery, Cassidy and Baker[8] demonstrated that its quality and readability are rather poor. Inherent to informed decision-making, orthopaedic surgeons must assess patients' understanding of their condition, educate available treatment options, and provide necessary resources to help guide patients. Further work must be done to ensure availability and readability of high-quality online information for orthopaedic patients. In order to optimize and tailor online content to the needs of these patients, such as those with ACL tears, it would be valuable to identify their greatest concerns and areas of curiosity regarding ACL surgery and the available modalities of treatment.

Google remains the most widely used search engine in the United States.[11] Machine-learning systems, specifically RankBrain and BERT (ie, Bidirectional Encoder Representations from Transformers), enable Google to identify search query data patterns and predict subsequent queries based on the initial search.[12-14] These pattern-recognition systems allow Google to generate a list of commonly asked questions associated with an initial search inquiry,[13] as well as provide a list of useful resources. These collections of inquiries and resources associated with a topic, such as ACL surgery, may be a useful surrogate for the most frequently asked questions by patients. Identifying what patients are asking and what types of resources are commonly accessible to them may help physicians understand patient concerns and the quality of information available.

Shen et al.[15] leveraged this information on Google to characterize what patients were asking relating to total joint replacement and assess the quality of information available. To date, this form of analysis has never been conducted for those with ACL tears inquiring about ACL reconstruction (ACLR) or repair. Therefore, the purpose of this study was to leverage Google's search algorithms to summarize the most commonly asked questions regarding ACL injuries and surgery. We hypothesized that the most frequent inquiries would pertain to expectations and activities after ACL injury or surgery.

Methods

Google's most commonly searched questions were used as a proxy to identify, on a large scale with increased generalizability, what questions patients are asking, in place of survey data. In January of 2022, the following search terms were entered into Google Web Search (www.google.com) using a clean-installed Google Chrome browser: "ACL injury," "ACL reconstruction," "ACL repair," "ACL surgery," "ACL tear," and "ACL." A clean-installed browser was used to minimize the effect of personalized search algorithms employed by Google Search. For each of the search terms, the list of frequently associated questions was refreshed until approximately 100 questions were generated. We chose 100 questions based on the precedent set in the existing literature.[8,15,16] A freely available data-mining extension (Scraper, version 1.7) was used to extract each question and its associated webpage to a database. Institutional review board approval was not required, as all study information is publicly available.

Two reviewers (Y.E. and J.H.) first categorized the questions according to Rothwell's classification system,[17,18] summarized in Table 1. Questions were then further classified into 1 of 14 topics relevant for ACL injury and ACLR: Specific Activities, Restrictions, Timeline of Recovery, Technical Details, Cost, Anatomy/Function, Diagnosis, Indications/Management, Risk/Complications, Pain, Longevity, Evaluation of Surgery, Injury Comparison, and Other. Descriptions for each of these topics can also be found in Table 1.

As previously reported in the literature, websites were categorized by source into the following groups: Commercial, Academic, Medical Practice, Single Surgeon Personal, Government, Social Media, and Other.[19,20] Definitions and examples are listed in Table 1. The *Journal of American Medical Association* (JAMA) Benchmark Criteria was used to measure website quality. JAMA Benchmark Criteria rates websites based on authorship, attribution, currency, and disclosure. One point is assigned for the presence of each component and totaled for a final JAMA score ranging from 0 to 4 (Table 2).[21] This instrument has been used in multiple studies to investigate the quality of online health information.[8,22-24] After the initial classification, discrepancies between the 2 reviewers were resolved by a third party (T.S.L.).

Statistical Analysis

Descriptive statistics and Pearson χ^2 tests were used to analyze nominal data using Microsoft Excel, Version 16.66 (Redmond, WA). Student's *t*-tests were performed to compare JAMA Benchmark Scores.

Results

A total of 606 questions were generated from the initial search. After duplications were removed, 273 unique questions associated with 204 websites were extracted and categorized. The top 12 most frequently asked questions for ACLRs are presented in Table 3.

The majority of questions fell into the Fact category (51.8%) using Rothwell's classification system (Fig 1A). The most popular topics were Indications/Management (20.2%), Specific Activities (15.8%), and Pain (10.3%) (Fig 1B). The most common types of websites searched were Medical Practice (27.9%) followed by Academic (23.5%) and Commercial (19.5%) (Fig 2A). Social media was the least searched, with 4.0%. Of the 3

Table 1. Rothwell Classification of Questions, Question Classification by Topic, Website Categorization, and JAMA Benchmark Criteria

Rothwell's Classification	Description
Fact	Asks whether something is true and to what extent, objective information Ex: Is ACL surgery covered by insurance?
Policy	Asks whether a specific course of action should be taken to solve a problem Ex: What exercise is good for a torn ACL?
Value	Asks for evaluation of an idea, object, or event Ex: How painful is ACL recovery?
Question Classification by Topic	**Description**
Fact	
Specific Activities	Ability to perform a specific activity or action after ACLR
Restrictions	Restrictions to activity or lifestyle during recovery or indefinitely
Timeline of Recovery	Specific questions regarding length of time for recovery milestones
Technical Details	Surgical procedure, includes specific questions about implants
Cost	Cost of surgery and/or rehabilitation postoperatively
Anatomy/Function	Specific questions regarding the structure and function of the ACL
Diagnosis	Questions regarding how one knows they have an ACL tear
Policy	
Indications/Management	Surgical indications and timing of surgery
Risks/Complications	Management of risks/complications during and after surgery
Value	
Pain	Pertains to duration, severity, and management of pain
Longevity	Specific questions regarding longevity of an ACLR
Evaluation of Surgery	Evaluation of the successfulness or invasiveness of ACLR
Injury comparison	Comparison between ACLR and other injuries in regard to severity, etc.
Website Categorization	**Description**
Academic	Institution with a clear academic mandate, including universities, academic medical centers, academic societies Ex: AAOS, Mayo Clinic, HSS
Commercial	Commercial organization that positions itself as a source of health information, includes medical device and pharmaceutical companies Ex: WebMD, Everyday Health
Government	Websites ending in.gov or maintained by a national government Ex: Medline, PubMed
Medical Practice	Local hospital or orthopedic practice without an academic affiliation Ex: New York Orthopedics
Single Surgeon Personal	Website built and maintained by individual surgeon. Excludes biography pages on institutional websites Ex: EdwinSu.com, DrRMarx.com
Social Media	Websites maintained by nonmedical organizations primarily designed for information sharing between internet users. Includes health blogs, internet forums, and support groups Ex: fitpro.com, silversneakers.com
JAMA Benchmark Criteria	**Description**
Authorship	Clearly identifiable author and contributors with affiliations and relevant credentials present
Attribution	References and sources clearly listed with any copyright information disclosed
Currency	Clearly identifiable posting date of any content as well as date of any revisions
Disclosure	Website ownership clearly disclosed along with any sponsorship, advertising, underwriting, and financial support

AAOS, American Academy of Orthopaedic Surgeons; ACL, anterior cruciate ligament; ACLR, anterior cruciate ligament reconstruction; HSS, Hospital for Special Surgery; JAMA, *Journal of the American Medical Association*.

websites classified as "Other," one was a newspaper, one was a nonprofit consumer advocacy organization, and one was ESPN. These websites were all associated with Fact questions regarding Cost and Timeline of Recovery.

The distribution of website sources stratified by question topics is summarized in Figure 2B. A detailed breakdown is available in Table 4. Fact, Policy, and Value questions were relatively evenly distributed across website sources. Question topics also were evenly distributed with the exception of Academic websites, which had disproportionately fewer questions on Specific Activities and a greater number of questions regarding Pain and Diagnosis ($P = .027$).

Average JAMA score was 2.67 ± 1.12 (Table 5). Commercial and Academic websites had the greatest JAMA scores (3.59 and 3.16, respectively) whereas websites associated with a Medical Practice or Single

Table 2. JAMA Benchmark Criteria

Criteria	Description
Authorship	Clearly identifiable author and contributors with affiliations and relevant credentials present
Attribution	References and sources clearly listed with any copyright information disclosed
Currency	Clearly identifiable posting date of any content as well as date of any revisions
Disclosure	Website ownership clearly disclosed along with any sponsorship, advertising, underwriting, and financial support

JAMA, *Journal of the American Medical Association*.

Surgeon had the lowest (1.70 and 1.62, respectively). Medical websites (i.e., Academic, Medical Practice, Single Surgeon Personal) and Government websites represented 75.0% of sources yet had a lower JAMA score than nonmedical websites (2.41 vs 3.46, $P < .001$).

Discussion

The most frequent question topics regarding ACL injury and surgery were those regarding indications for ACLR, followed by activities after ACLR and pain associated with surgery. The majority of websites were Medical Practice (27.9%) websites according to Rothwell's criteria, although these were "low-quality" per their average JAMA score (1.70). Approximately 25% of websites were commercial or nonmedical. Despite Academic websites exhibiting "high quality" with a high JAMA score, information on the most commonly asked questions (eg, cost of ACLR, activities after ACLR) was scarce. These results highlight the need for further development of high-quality resources for patient education surrounding ACL injury management.

What Topics Are Most Concerning to Patients With ACL Injury?

The most commonly asked question regarding ACL injury and surgery was: "What is the cost of ACL surgery?" In the pediatric population, Lee et al.[25] reported on a continuing lack of ACLR price transparency by hospitals and providers despite enactment of policies meant to address this issue. Combined with the relative financial strain associated with surgical procedures, this may explain why patients seem to most frequently ask about cost in this study. Furthermore, the differences that exist in quantifying health care costs (eg, institutional charges vs insurance reimbursements vs actual cost of care among others) as well as the nondisclosure agreements involved in contracts between health care institutions and implant vendors further murky the waters of ACLR cost availability. Addressing these barriers among others potentially leads to more transparency, and, considering the study results, it is possible that this transparency for ACLR and associated procedures costs in frequently used resources can provide a great service to patients.

Following cost, the most commonly asked questions, in descending order, pertained to indications for, activities after, and pain associated with ACLR. Of the 12 most frequently generated questions (Table 3), the majority seem to emanate from patients trying to decide whether they should undergo ACL surgery. Although it is unknown whether these queries occur before or after orthopaedic consultation, this information may serve as an impetus for surgeons to dedicate time to discussing indications for surgery, such as ACL reconstruction or repair, in addition to providing resources related to costs associated with surgery. These may be important topics to address early in consultation and maximize shared decision-making.

Importantly, patients electing to pursue surgery are increasingly concerned about physical limitations after surgery and when they will be able to return to play sports, which varies considerably for patients based on the activity/sport of interest and the surgeon.[26-28] Preoperative expectations are essential to discuss. With a high number of searches inquiring about activities after surgery, these results highlight the need for physicians to discuss expected limitations and timeline of recovery. The most frequently asked questions also included queries regarding activities of daily living (eg, toileting), not necessarily sports or higher-level activity. Furthermore, Google users commonly inquire about postoperative pain, which is subjective and multifactorial.[29-32] Previous literature has demonstrated that pain perception and catastrophizing may change throughout the course of ACLR rehabilitation and may influence outcomes.[31,33-35] Although multimodal analgesia renders postoperative pain manageable,[36-38] expectation-setting can lead to improved postoperative pain perception, outcomes,[39] and avoid dissatisfaction postoperatively.[40] These findings stress the importance of clear discussions about expectations after surgery, such as activity limitations, pain experiences, and timelines of recovery.

Quality and Transparency of Online ACL Information

The source of information for patients with ACL injury can vary in quality and transparency. The JAMA score was developed originally to assess the quality of online information. This study interestingly found that

Table 3. Top 12 Most-Popular Search Questions for ACL

1.	What is the cost of ACL surgery?
2.	How long does an ACL take to heal without surgery?
3.	Is ACL surgery a major surgery?
4.	What is the fastest ACL recovery?
5.	Will my knee ever be the same after ACL surgery?
6.	Does ACL surgery leave a scar?
7.	How do you poop after ACL surgery?
8.	What happens if you don't repair a torn ACL?
9.	Is ACL surgery good for life?
10.	How do you tell if ACL is torn or sprained?
11.	How long does ACL surgery take?
12.	Where is ACL pain located?

ACL, Anterior cruciate ligament.

the average JAMA score was greater for commercial and nonmedical websites compared with medical and governmental websites. Most websites were of the Medical Practice category, but their average JAMA score was one of the lowest (1.70). Single surgeon websites had the lowest JAMA score (1.62) among all website types. These results must be interpreted with caution, because the ability of the JAMA score to identify website accuracy and quality has been criticized for being limited. This is because the JAMA score includes parameters (ie, authorship, attribution, disclosure, currency) that are scored based on their presence

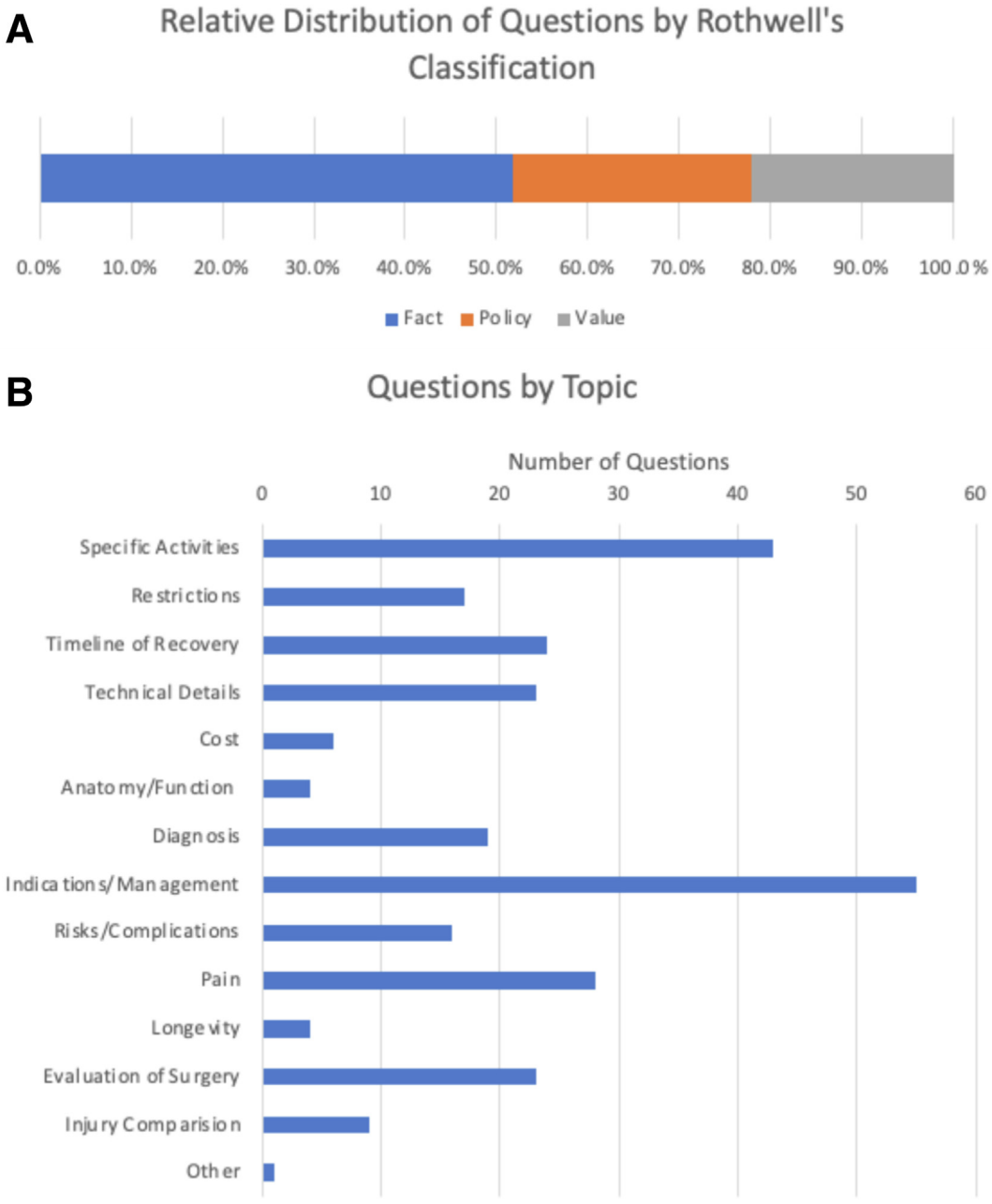

Fig 1. Relative distribution of questions by Rothwell's classification and by topic. (A) The percentage of questions belonging to Fact, Value, or Policy classifications. (B) The number of questions in each topic category.

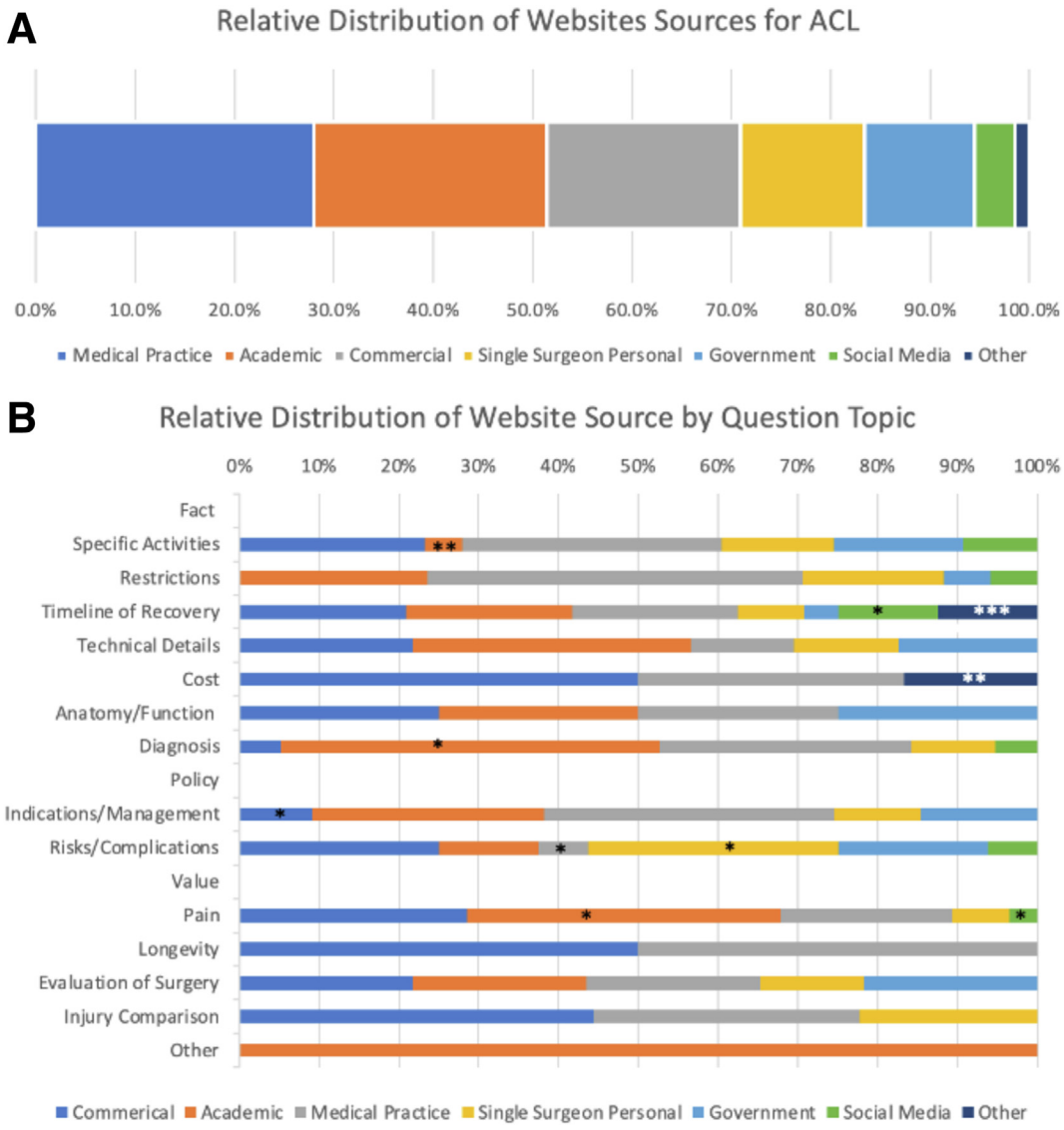

Fig 2. Relative distribution of websites. (A) The percentage of websites belonging to the 7 groups. (B) The percentage of questions in each website category. (ACL, anterior cruciate ligament.)

in a resource rather than the inherent quality or value of said parameters. For example, a recent website that is managed by a self-identified nonexpert citing studies with poor methodology can theoretically attain a score of 4 because it (1) identifies the author, (2) provides citations, (3) provides disclosure, and (4) is recent. Instead, the JAMA score serves more as a measure of website transparency,[15,21] which nonetheless may still have a significant impact in the decision-making of the patient.

Although Academic websites exhibited a greater average JAMA score (3.16), the pages generated by Google's algorithm contained limited information regarding activities after surgery, the second most frequently inquired topic among patients, compared with other website types (only 4.7% of sites addressing the topic). In addition, no Academic website in the study contained information on the most frequent inquiry: the cost of ACLR. These results, together with the lower JAMA scores associated with medical and governmental websites, expose the need for more transparency and availability of information associated with ACL injury and ACLR available online.

In addition, it is important to note that the JAMA score, albeit providing a measure of website transparency, does not assess readability of a resource. Although the average adult in the United States has a reading level no greater than the eighth grade, a study published by Akinleye et al.[41] demonstrated that, of the 5 most common arthroscopic procedures, ACLRs were associated with the greatest reading level of almost eleventh grade. This presents an inherent problem for

Table 4. Distribution of Questions by Website Source and Topic

	Commercial	Academic	Medical Practice	Single Surgeon Personal	Government	Social Media	Other	Total	*P* Value
Fact	28	29	40	17	14	9	4	141	
Specific Activities	10	2	14	6	7	4	0	43	.06
Restrictions	0	4	8	3	1	1	0	17	.35
Timeline of Recovery	5	5	5	2	1	3	3	24	**<.01**
Technical Details	5	8	3	3	4	0	0	23	.52
Cost	3	0	2	0	0	0	1	6	**.03**
Anatomy/Function	1	1	1	0	1	0	0	4	.94
Diagnosis	1	9	6	2	0	1	0	19	.17
Policy	9	18	21	11	11	1	0	71	
Indications/Management	5	16	20	6	8	0	0	55	.18
Risks/Complications	4	2	1	5	3	1	0	16	.14
Value	16	17	15	6	5	1	0	60	
Pain	8	11	6	2	0	1	0	28	.20
Longevity	2	0	2	0	0	0	0	4	.60
Evaluation of Surgery	5	5	5	3	5	0	0	23	.66
Injury Comparison	4	0	3	2	0	0	0	9	.31
Other	0	1	0	0	0	0	0	1	
Total	78	99	112	51	46	13	4	403	

Bold indicates statistical significance ($P < .05$).

patients undergoing ACLR that may lead to them to search for information that is easier to understand despite potentially compromising the quality of information. Alongside the relative lack of transparency in even the most credible websites in theory, it is evident that there is room for quality improvement in the dissemination of information regarding ACL injury and surgery.

Study Implications

Internet search analytics can be an effective method of granularly characterizing patient inquiries regarding a specific injury or intervention. Shen et al.[15] identified the most frequently asked questions for patients undergoing total knee and hip arthroplasty. The most popular question categories for these procedures were regarding specific activities (23.5%) and indications or management (15.6%). Compared with total hip arthroplasty, those asking about total knee replacement, in contrast, more often inquired about pain, indicating variability of question type depending on the procedure. Our study similarly found that patients most commonly ask about indications and management (20.2%) as well as specific activities (15.8%) after ACL injury and/or ACLR. However, it would be interesting to further analyze whether queries differ according to procedure type (eg, primary ACLR vs repair vs revision ACLR). In collection, these results may ultimately assist surgeons in tailoring preoperative discussions before ACL surgery and inform the development of further high-quality resources to improve patient education.

Table 5. Distribution of Website Categories for ACLR With JAMA Benchmark Score

	JAMA Score*	n	%
Total websites	2.67 (1.12)	272	
Website classification			
Commercial	3.59 (0.70)	53	19.5%
Academic	3.16 (0.92)	64	23.5%
Government	3.53 (0.73)	30	11.0%
Medical Practice	3.00 (0.43)	76	27.9%
Single Surgeon Personal	1.62 (0.54)	34	12.5%
Social Media	3.00 (0.43)	11	4.0%
Other†	2.80 (0.40)	4	1.5%

ACLR, Anterior cruciate ligament reconstruction; JAMA, *Journal of the American Medical Association*.

*JAMA score reported as mean (standard deviation).

†Website sources in this category were newspaper (n = 1), ESPN (n = 2), and nonprofit consumer advocacy organization (n = 1).

Limitations

This study was not without limitations. The dynamic nature of online searching means that the most frequently asked questions generated by Google's algorithm can change throughout time, which would be difficult to capture with this study design. Queries are also inevitably variable according to the individual that is using the search function as well as the location where searching occurs (eg, the frequency of inquiring on ACLR cost varies between an affluent neighborhood in a developed country and a low-income resource-scarce community in a third world country). This study attempted to control for these confounders by entering multiple queries and extracting a large sample of generated questions to come up with as generalizable of a subset as possible. The use of a clean-installed web browser attempted to mitigate the effects of individual

search history on the questions generated by Google. The categorization of questions, although based on previous literature, still contains some level of arbitrary assignment, subjective interpretation, and is subject to topic overlap. We attempted to address these issues by having multiple reviewers, assessing their agreement, and using an experienced senior author as a third party to settle disagreement in classification. Although another limitation is the lack of formal interobserver agreement data (eg, kappa statistic), the presence of this third party mitigated the potential confounding effects of interobserver discrepancies in our results. In addition, the use of Google as a surrogate for the most frequent inquiries of patients with ACL injuries may not fully capture the full spectrum of questions and concerns and therefore may limit generalizability. Although survey data may directly answer these questions, these results would likely be confined by smaller sample sizes and therefore limit generalizability. The present methodology leverages the high-volume input of Google's search engine to capture a broader array of searches, which increases generalizability compared with a smaller survey. Search analytics should not be a substitute for listening to the questions and concerns of patients at clinical encounters and orthopaedic consultations, though. Finally, the JAMA score may not be the most complete or ideal tool for assessing the quality of information. Recent literature states that the use of the JAMA score may be better suited to represent source transparency rather than quality.[17,21] However, the JAMA score still remains the most-well established tool for assessing online health information.[8]

Conclusions

The most-searched questions on Google regarding ACL tears or surgery related to indications for surgery, pain, and activities postoperatively. Health information resources stemmed from Medical Practice (27.9%), followed by Academic (23.5%) and Commercial (19.5%) websites. Medical websites had lower JAMA quality scores compared with nonmedical websites.

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