




Modern Internet Search Analytics and Osseointegration: What are Patients Asking and Reading Online?

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ABSTRACT

Background: Osseointegration (OI) limb has been performed for over 30 years and is an example of an advance in technology and surgical technique which has led to improvements in patient mobility and quality of life. An increasing number of patients seek information about osseointegration. The aim of this study was to categorise the most frequently asked questions by patients using the Google search engine and the most frequently accessed websites with the highest return on answers. The secondary aims of this study were to assess the quality of the information provided on those websites and to stratify, by category, which websites provide the best quality information.

Materials and methods: Ten permutations and conjugations of the word 'osseointegration' were entered into Google. The first fifty 'People also ask' and associated websites by Google's machine learning and natural language processing engine were collected for each search term. The Rothwell classification system of questions by topic (Fact, Value, Policy) and websites by category was used (Commercial, Academic, Medical Practice, Single Surgeon Personal, Government, Social Media). Website quality was assessed using the Journal of the American Medical Association (JAMA) benchmark criteria (Likert-style rating 0-4). Pearson's Chi-squared and Student's *t*-tests were performed for statistical analysis as appropriate (significance, $p < 0.05$).

Results: The 10 search terms generated 454 questions and referenced 408 websites. Of the 454 questions generated, the most common question categories were fact (70.8%), value (19.2%), and policy (10%). The most common website type was social media (37.4%). The most common question types were technical details (30.4%), specific activity (20.6%), and cost (14.1%). Only 1.6% of questions related to risks and complications. Generally, website quality was poor with 64.1% having a JAMA score of 0 or 1. Websites that were categorised as 'Government' had the highest overall JAMA scores: 71.4% had a score of 4.

Conclusion: Based on Google search engine's results, the most commonly asked questions about osteointegration related to technical details, specific activities and cost; only 1.6% related to risks and complications. Interestingly, social media websites represented the highest volume of search result referrals. Overall, the quality of websites was poor with the most factual information coming from governmental websites.

Keywords: Cost, Google, Online health information, Osseointegration, Prosthesis, Search analytics.

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INTRODUCTION

Clinicians and patients have unprecedented easy access to masses of information. The ability to search a term so quickly and effortlessly has enabled patients to become better informed. Given the volume of information now available, modern search analytics attempt to provide the best sources of information. Google Web Search continues to be the most used search engine for those wishing to learn more about medical conditions; it accounts for 84% of computer internet searches and 96% of mobile searches.^{1,2} In 2015, Google introduced a machine learning algorithm, RankBrain, to improve search queries and provide individual suggestions.³ To this was added a natural language processing system [Bidirectional Encoder Representations from Transformers ((BERT))] with the result being better individualised information for Google users.

Limb loss from amputation is a life altering challenge. Lower limb prosthetics have advanced with improvements in the materials and fit of the limb to the prosthetic socket. However, despite this, the interface between the limb and prosthesis continues to be a source of discomfort with issues of sweating, skin irritation, and its impact on the speed of walking being the most common issues reported.⁴ Consequently, alternative techniques have been developed to improve this interface, such as osseointegration

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(OI), from which there is a direct connection between living bone and the prosthesis. Osseointegration is used in several specialities including dentistry, maxillofacial surgery, bone-anchored hearing aids as well as for prosthetic limbs. Whilst OI has been performed for the last 30 years, improvements in technology and surgical techniques have led to more recent improvements in patient outcomes and quality of life.^{5,6} This improvement in outcomes has been mirrored by the large increase in the number of publications in the last 10 years.⁷

In the last 20 years, the number of health-related searches has gone from approximately 6.75 million per day to over one billion, accounting for 7% of all Google daily searches.^{8,9} Nearly, two-thirds of orthopaedic patients use the internet to search for orthopaedic information.¹⁰ As outcomes from OI have improved, there have been parallel changes in patient acceptability and accessibility. This has produced an increase in the number of people seeking to know more. The sources and quality of this information are important to enable patients to make informed decisions and understand the benefits as well as the risks and complications. The purpose of this study was to better understand the most frequent questions asked regarding OI from modern search analytics, what sources are being used to inform patients, and the quality of information received.

MATERIALS AND METHODS

The search terms related to OI were entered into Google Web Search in a cleanly installed browser using the web search engine Chrome. Ten search terms were utilised (Table 1). Nine of the search terms generated 50 unique results per search term, whilst the tenth search term did not generate relevant search results pertaining to the topic. The ‘People also ask’ list was refreshed to generate 50 queries per search term. If duplications occurred, the list was refreshed to have 50 original search results per each search term.

The list of ‘People also ask’ was generated and analysed. This information was extracted using a web scraper programme (Webscraper, IO). These questions were then analysed according to a previously described classification system by Rothwell (Table 2).^{11,12} The websites were subcategorised into six groups. These groups were commercial, academic, medical practice, single surgeon or personal accounts, government, and social media. Examples of a commercial website include those involved in profit making without patient care. The academic websites were university affiliated websites with a strong academic focus. The medical practice websites consisted of groups of practitioners without a particular academic affiliation. The single surgeon consisted of a personal promotion website and did not include a surgeon with an affiliated practice or on an academic website grouping. The government websites were those run by the government such as the National Institute for Health in the United States of America. Social media websites consisted of platforms such as forums, or social media personal accounts where information was disseminated. The Journal of the American Medical Association (JAMA) rating scores websites on four criteria using agreed definitions (Table 3).¹³

Statistical analysis was conducted using SPSS version 27, IBM Corp. (2020) Armonk, NY.

The primary author (EPM) collected the list of questions and websites of ‘People also ask’. Two reviewers then used the Rothwell classification to categorise the questions by topic and websites by category. Inter-observer reliability analysis was performed with an agreement of 0.96 for question topics and 0.82 for JAMA total score.

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The websites were scored using the JAMA Benchmarking system. Nominal data was analysed using the Chi-square test whilst the Student’s *t*-test was utilised for comparison of the JAMA benchmark scores. Ethical approval was not sought for this research project and there was no funding available.

RESULTS

The 10 search terms generated 454 questions and referenced 408 websites. There were four questions that were generated seven times and two websites that were referenced eight times (Tables 4 and 5).

Question Categories

Of the 454 questions generated, the most common Rothwell classification categories were fact (70.8%), value (19.2%), and policy (10%). Of those questions classified as fact, 30.4% of questions were related to technical details, 20.6% to specific activity, 14.1% to cost, 4.8% to timeline of recovery, and 0.7% to restrictions. Of those questions classified as policy, 8.4% were related to indications and 1.6% to risk or complications. Of those questions classified as value, 1.7% were related to pain, 7.8% to longevity, and 9.7% to evaluation for surgery. The most common website categories were social media (37.4%), single surgeon websites (22.3%), and government websites (18.9%). The other websites comprised 21.4% (academic 10.8%, commercial 7.4%, medical practice 3.2%) (Table 6).

There was no statistically significant difference amongst the website categories for fact-based searches except for government (*p* = 0.03) and social media websites (*p* = 0.001). Eighty-one percent of the questions from social media sites were fact-based questions. Further analysis of the social media websites showed a statistically significant difference (Fischers exact test) to cost (*p* = 0.001), specific activity (*p* = 0.001), and technical details (*p* = 0.003). This was not found with the other sub-categorisations (timeline of recovery *p* = 0.144 or restrictions *p* = 0.685). For policy-based searches, there

Table 1: Search terms

Search term	Results
Osseointegration	50
Bone-anchored implant	50
Bone-anchored prosthesis	50
Osseointegrated implant	50
Osseointegrated prosthesis	50
Percutaneous osseointegrated implant	50
Percutaneous osseointegrated prosthesis	50
Transcutaneous osseointegrated prosthesis	50
Transcutaneous osseointegrated prosthesis system	50
TOPS	0 relevant



Table 2: Rothwell classification of questions, question classification by topic and website categorisation

<i>Rothwell's classification</i>	<i>Description</i>
Fact	Objective information. Is something true? Example: When will I walk again after osseointegration surgery?
Policy	Should a specific action/course be taken to solve an issue Example: Should I do prehab before getting osseointegration surgery?
Value	Evaluates an idea/object or event Example: Does osseointegration surgery let you walk normally again?
<i>Question classification by topic</i>	
Fact	
• Specific activities	Particular activities after osseointegration surgery e.g., running/walking/swimming
• Timeline of recovery	Questions about length of time to achieve goals/milestones
• Restrictions	Questions about limitations e.g., swimming/running
• Technical details	Questions about the mechanics/what the materials are made of
• Cost	Cost of surgery/implant
Policy	
• Indications/Management	Questions about patient selection/indications/staging of procedures
• Risks/Complications	Questions about the risks and complications in perioperative and postoperative period
Value	
• Pain	Questions about pain/pain relief
• Longevity	Questions about how long the prostheses last
• Evaluation of surgery	Questions about levels of satisfaction/success after it
<i>Website categorisation</i>	
Commercial	Companies which provide health information in a sponsored fashion. Example: WebMD
Academic	Institutions with strong university affiliations Example: HSS/Mayo Clinic
Medical practice	Group practices not majorly affiliated with academic links Examples: New York Orthopaedics
Single Surgeon Personal	Single practitioner-maintained Example: noelhendley.com
Government	If a website is maintained by the government or a national body. Example: PubMed
Social media	These include blogs/social media platforms/support groups/testimonials Examples include: amputee-coalition.org

Table 3: JAMA

<i>JAMA benchmark criteria</i>	<i>Description of the criteria</i>
Authorship	Must be named with affiliations and credentials
Attributions	Sources/References with copyright information to be disclosed
Currency	When was the information posted as well as date of any revisions
Disclosures	Financial support/sponsorship/ advertising disclosed

was no statistically significant difference between the websites except for government websites (25.9% policy questions in government vs 6.3% in non-government websites, $p = 0.001$). Only 2% of policy questions came from social media websites vs 14.8% from other websites ($p = 0.001$). In terms of value-based questions,

53.8% of the questions came from medical practice websites vs 19.6% from other sites ($p = 0.003$).

JAMA Scores

The majority (64.1%) of websites provide no or insufficient information (JAMA score zero or one) regarding authorship, attribution, disclosure, and currency. A JAMA score of two was seen in 10.8% of websites, JAMA score of 3 in 7.7% and JAMA score of 4 in 17.4%. Currency was the most reported JAMA attribute (51.8% of all websites), followed by authorship (44.7%), attribution (27.9%), and finally disclosure (23.2%). Websites that were categorised as government had the highest JAMA scores of which 71.4% had a score of 4. This compares with 84.6% of websites that were categorised as Medical Practice which had a JAMA score of 0. There was a statistically significant difference in the scores between the government websites vs the other websites using the Chi-square test. In all other categories, zero was the most common JAMA score except for commercial websites where 80% had a score of 3 or greater (Fig. 1).

Table 4: Top 10 most frequently asked questions

Question	No. of times questions asked
Can you shower with a prosthetic leg?	7
How long does osseointegration surgery take?	7
What is an osseointegrated prosthetic?	7
Why do prosthetics cost so much?	7
Can you run with osseointegration?	6
How long do prosthetic legs last?	6
How much does osseointegration surgery cost?	6
How long does it take to recover from osseointegration surgery?	5
What are the different types of below knee prosthesis?	5
What are permanent prosthetic legs?	5

Table 5: Top 10 most frequently referenced websites

Website	No. of times website referenced
www.hopkinsmedicine.org/health/wellness-and-prevention/what-to-know-before-getting-prosthetic-leg	8
www.lawall.com/blog/how-much-does-a-prosthetic-leg-cost	8
www.webmd.com/a-to-z-guides/definition-amputation	6
www.thecoldwire.com/why-are-prosthetics-so-expensive/	6
www.osseointegration.org/faq/	6
www.ncbi.nlm.nih.gov/pmc/articles/PMC6939984/	6
www.hss.edu/condition-list_osseointegration.asp	6
https://journals.lww.com/prsgo/Fulltext/2021/10001/A_Solution_to_Poorly_Tolerated_Lower_Limb.167.aspx	6
www.uchealth.org/today/osseointegration-surgery/	5
www.amputee-coalition.org/resources/prosthetic-faqs-for-the-new-amputee/	5

Table 6: Website categories

Category	Percentage
Social media	37.4
Single surgeon	22.3
Government	18.9
Academic	10.8
Commercial	7.4
Medical practice	3.2

DISCUSSION

The most commonly asked questions about OI were what is an OI prosthetic, how long does the surgery last, can you shower with a prosthesis and what is the cost? Whilst the most commonly referenced websites were from healthcare, nearly two-thirds (64.1%) of websites had no or insufficient information on authorship, attribution, disclosure, and currency (JAMA score 0 or 1). Interestingly, social media websites are the most main source of information on OI. To the best of our knowledge, this is the first study to examine what patients are searching for related to OI and from what sources the information is obtained.

Approximately, 150,000 people undergo a lower extremity amputation in the United States each year.¹⁴ Use of a prosthesis has been shown to improve quality of life; however, issues from the interface between the limb and the prosthesis continue to pose a problem. Some studies have shown higher quality of life scores with OI prostheses than conventional socket-suspended prostheses (SSP).¹⁵ This has led to more people seeking to know more about OI; the top questions asked were an explanation of OI, the nature of OI surgery, the cost, and the practicalities of using the prosthesis (can you shower, can you run?). Costs vary amongst health systems and are difficult to calculate accurately due to the multiple facets involved in OI (surgical, prosthetic, rehabilitation, and medical care). A study by Black et al. of 27 patients in the United States estimated that the median preoperative costs were \$6216, operative costs of \$48,247, and yearly postoperative costs of \$2626, provided no complications or preimplantation surgical revision occurred.⁵ A study from Australia found the OI prosthesis to be on average 21% more than SSPs. However, the quality adjusted life years (QALYs) increased by 17% in those with an OI prosthesis. Osseointegration prostheses were also found to be cost-effective in 88% of participants in the study and a cost-saving in 19%.¹⁶ Whilst complications and implant survival are the focus of many clinical studies, none of the top 10 questions asked related to the potential complications or the main issues faced with such prostheses. Skin problems and skin infections are the most common complications with OI with rates of 28–55% reported in a systematic review by van Eck and McGough.¹⁷ However, surgical techniques have improved with a focus on removing redundant skin, having a snug muscular skin seal at the skin-implant interface.¹⁸ A large follow-up study of 485 patients showed 59 (12.2%) required at least one operative intervention for infection.¹⁹

Whilst the internet has greatly improved the access for patients seeking information on OI, the quality of this information is worryingly poor. Social media platforms are how many people access their information now and there are issues around the quality and misinformation these may provide. Social media usage amongst the US population is high with at least 78% of the population having at least one social media account.²⁰ Patient autonomy is important in decision-making and accurate information is key to this process. The number of health information-related searches has increased to almost one billion per day.⁹ The patient–physician interaction is important and part of the consent process involves trust.²¹ The position statement on the code of conduct within social media for organisations of the medical profession advises how to interact on this platform and suggests separating personal and professional accounts.²¹

Social media has the potential to provide an excellent forum for debate. However, the lack of governance around contributors,

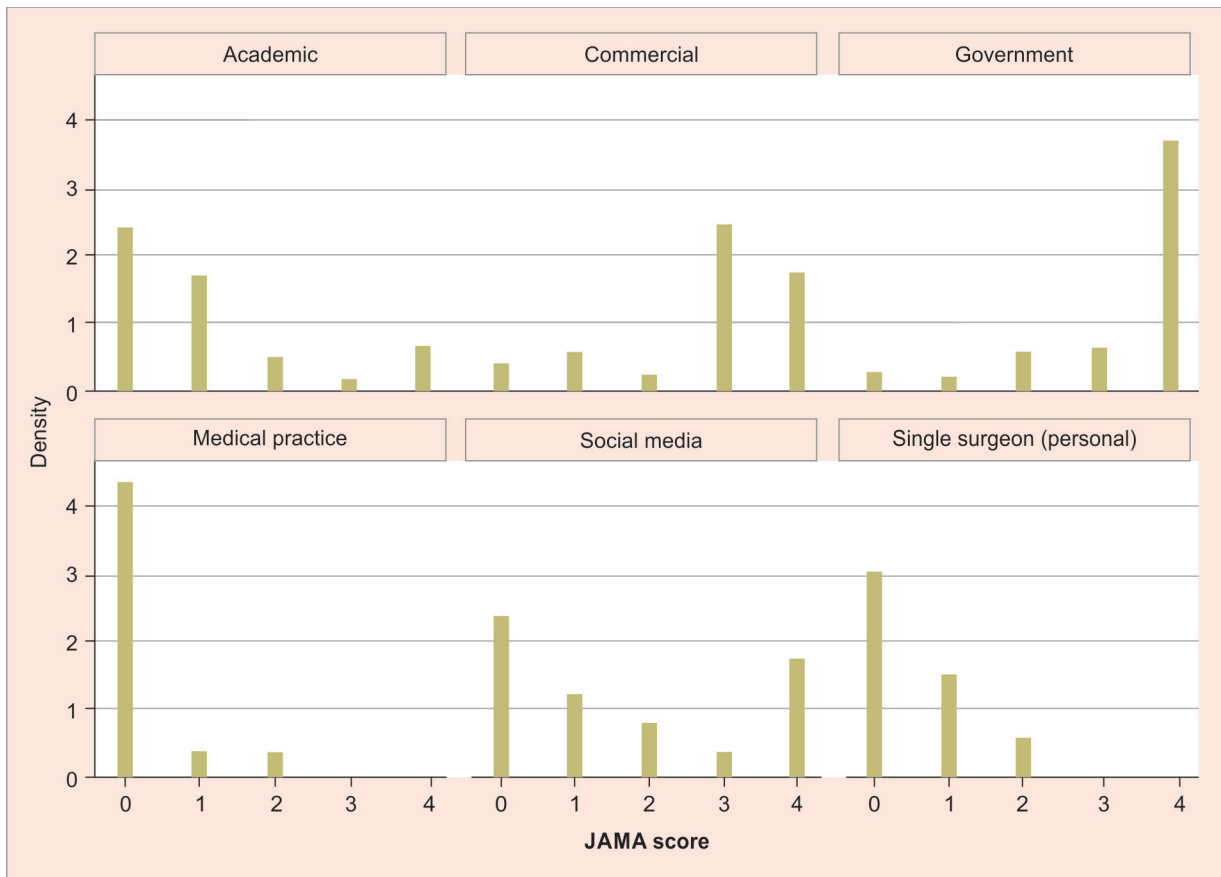


Fig. 1: JAMA score by website category

misrepresentation of parties’ credentials, and the potential for misuse exist. This is a difficult forum to regulate. Patients actively seek out information online; trustworthy information that is accessible online is of value to patients who are vulnerable. The same standards of medical ethics need to be held online as in person when providing information. A study by Duymuş et al. of 321 Turkish orthopaedic surgeons found that surgeons operating in private practice were more likely to communicate with their patients by e-mail, cross-platform messaging services or private website forums.²² Orthopaedic surgeons can improve engagement with their social media platforms by including hashtags such as ‘#ortho’. A study of 25 influential Instagram accounts with 250 Instagram posts found that the most visited posts were those which evoked an emotional response or involved questions and answers.²³ Similarly, the findings of this study point to forums for posting questions being popular but the quality of information on these forums is uncertain.

Gaps exist in terms of monitoring the recent explosion of content on social media platforms.²⁴ The JAMA benchmark is the best marker for information on the internet currently.¹³ A systematic review by Chen et al. attempted to evaluate and quantify the impact of internet-based searches. There are three recognised types of users: health institutions, health researchers or professionals, and the general public. It highlighted 10 types of social media use, whereas the JAMA benchmark has four sub-categorisations which are applied to all websites. Twitter was the most used platform for individual illnesses overall. However, this study on OI found more patients engaged on social media

discussion forums. Social media posts can provide insight into the cognitive and behavioural responses in relation to OI procedures and the process. Health information can be disseminated quickly as compared with traditional routes of in-office appointments. Health institutions often have testimonials, links and YouTube videos to increase patient awareness. That said, the COVID-19 pandemic highlighted both the impact of misinformation and the need for rapid dissemination of correct information.²⁵ Studies during previous outbreaks such as measles have highlighted the importance of physicians providing transparent information about vaccinations and increasing engagement with public health processes. Younger patients engage with different social media platforms in comparison to older patients.²⁶ Younger patients were more likely to use YouTube instead of using government sponsored or academic platforms. Hashtags may be a way to engage emotionally with this demographic as proven by other studies.²³ The needs of all demographic sectors must be addressed. Our study highlights the diverse nature of information sources patients utilise and the top questions they research. Academic institutions can utilise this to tailor the information which is currently available whilst considering patients’ concerns. At our institution, we have designed our website to include basic information, case examples, testimonials, social media feed, and scholarly publications to best address patient education.

This study is not without limitations. Only one search engine was utilised; this design is replicated in other studies as Google searches account for over 85% of all searches.²⁰ With our searches performed using Google, other search engines may generate

different results. This study is not able to evaluate the impact of social media on patient choices with respect to their health intervention. It is acknowledged that the JAMA benchmark is the best available tool currently available. However, some of the social media platforms will score poorly on this tool despite addressing some of the patients fears. The lack of regulation of social media usage and provision of information by non-physician parties creates challenges in addressing the wider field.

Another limitation is that the web searches were performed in January 2023 and the information on the web is updating constantly. Given that social media provided such a high proportion of available information, searches performed on each platform may provide very different themes. An investigation into social media specifically may be warranted in a future study of internet information of OI. A major strength of this study is the recognition that a high proportion of information on OI comes from personal sources such as social media, potentially creating a bias away from scientifically evaluated data towards that of personal experiences by highly visible individuals on the internet. This indicates that patients need more accessible information than is currently provided on professional websites.

Osseointegration offers an alternative option to the traditional socket suspension prosthesis. Patients are seeking more information as an increasing evidence base for its use grows. Understanding the types of questions patients ask on the internet about OI can inform clinicians. The most commonly asked questions about OI relate to technical details, specific activities and cost. Our study found that social media websites were the main source of patient information. There is a need for orthopaedic websites and organisations to adapt to better inform patients.

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